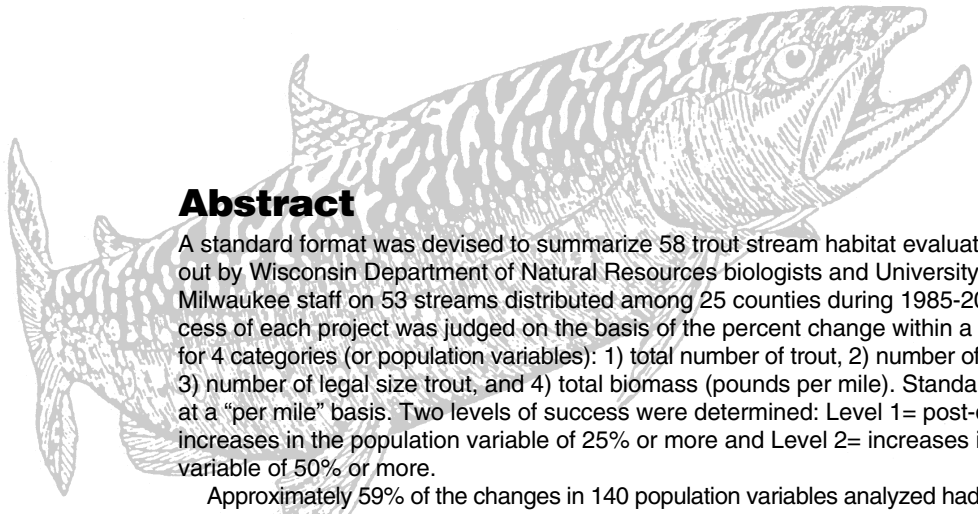
WISCONSIN DEPARTMENT OF NATURAL RESOURCES

RESEARCH REPORT 187

April 2004

A Compendium of 58 Trout Stream Habitat Development Evaluations in Wisconsin–1985-2000[1]

by **Ed L. Avery**
Bureau of Integrated Science Services
Waupaca, WI



Abstract

A standard format was devised to summarize 58 trout stream habitat evaluations carried out by Wisconsin Department of Natural Resources biologists and University of Wisconsin-Milwaukee staff on 53 streams distributed among 25 counties during 1985-2000. The success of each project was judged on the basis of the percent change within a treatment zone for 4 categories (or population variables): 1) total number of trout, 2) number of trout ≥6 inches, 3) number of legal size trout, and 4) total biomass (pounds per mile). Standardization was at a "per mile" basis. Two levels of success were determined: Level 1= post-development increases in the population variable of 25% or more and Level 2= increases in the population variable of 50% or more.

Approximately 59% of the changes in 140 population variables analyzed had Level 1 success after habitat development; 50% had Level 2 success. Total abundance of trout met Level 1 success in 43% of the treatment zones. Success rate at Level 2 was found in 31% of the treatment zones. Abundance of legal size trout achieved success rates of 65% and 62% at Levels 1 and 2, respectively. In treatment zones with allopatric populations of brook trout or brown trout, success rates were similar. In sympatric populations, brown trout responded much more positively than brook trout did to habitat development.

Habitat development techniques employed were grouped into 9 categories based on the predominant techniques. The beaver dam removal category, in treatment zones supporting allopatric brook trout populations, achieved the highest success rates. In sympatric trout populations, the "Wisconsin-style" bank cover and current deflector category achieved the best success rates. The channel excavation with whole log cover and boulders category achieved good results regardless of the trout species present. The bank cover logs and current deflectors category achieved excellent success in high gradient (1-3%) streams.

Average empirical post-development changes for populations of trout in 58 treatment zones included a 13% decline in total abundance of trout (from 1,323 per mile to 1,125 per mile), a 65% increase in trout ≥6 inches (from 208 per mile to 344 per mile), a 25% increase in legal size trout (from 291 per mile to 363 per mile), and a 63% increase in biomass (from 100 lbs. trout per mile to 163 lbs. trout per mile. Elements of this study and a similar Wisconsin study from 1953-85 were consolidated to provide 103 case histories detailing the results of habitat development on 82 different trout streams in 36 Wisconsin counties. Composite analyses not only provide near identical (Levels 1 and 2) success rates for 244 trout population variables but also provide fisheries managers with habitat development choices segregated by regions in the state.

[1] Includes one study completed during 1964-67.

Contents

Introduction, 1

Methods, 2

Results and Discussion, 5

Management Application and Implications, 17

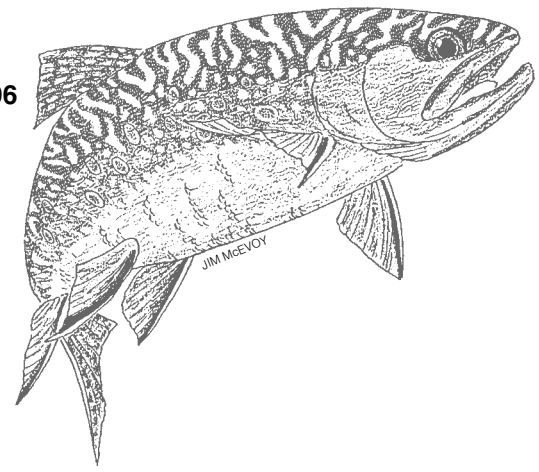
Summary, 19

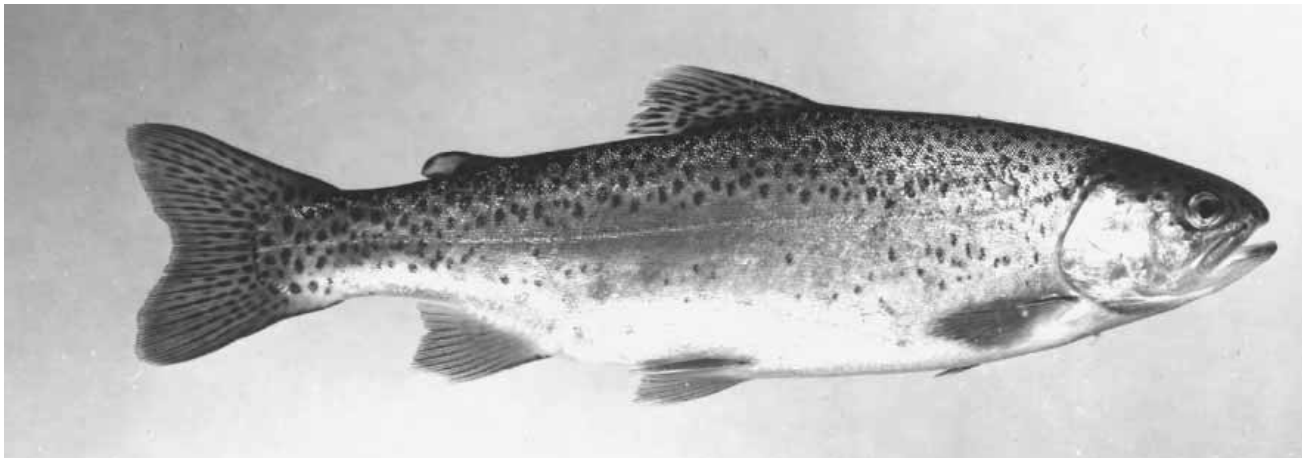
Case Histories, 20

Glossary of Habitat Development Techniques, 81

Appendices, 91

Literature Cited, 96





DNR PHOTO

Introduction

In 1977, legislation was passed in Wisconsin that requires anglers (ages 16-65) fishing for trout in inland waters to purchase an annual trout stamp. Revenue received from sales of these trout stamps is reserved exclusively for trout habitat development projects. During fiscal year 2001, the sale of 140,888 trout stamps ($7.25 each) generated $1,001,526.00[2] to be spent by the Wisconsin DNR on trout stream habitat development projects (R. Raftery, Wisconsin Department of Natural Resources, pers. comm. 2001).

In 1988, Hunt (1988) published a compendium of 45 trout stream habitat development evaluations in Wisconsin from 1953-85. In that report, Hunt (1988) summarized the history of trout stream habitat management in Wisconsin and the research that formed the basis for previous manuals on the principles and techniques for enhancing trout stream habitat in Wisconsin (see O'Donnell and Threinen 1960, White and Brynildson 1967). Hunt's (1988) compendium was the first major effort to compile both published and unpublished habitat development evaluations in Wisconsin. It also represented the first major effort to: 1) standardize reporting of results from trout habitat evaluations statewide, 2) objectively quantify the "success" or "failure" of such projects, and 3) interpret management implications from this era of trout fishery management based on the overview that the collection of documents provided.

Many procedures are used to restore and improve trout stream habitats in Wisconsin. The most common techniques include: current (wing) deflectors, several types of bank cover devices, mid-channel half-log or whole log structures, rock rip-rap, mid-channel placement of boulders (boulder retards), removal or thinning of woody stream bank vegetation (particularly alder brush), brush bundles or mats along the stream edges, and stream bank fencing to exclude livestock. Many of these techniques are defined and lavishly illustrated with color photographs in *Trout Stream Therapy* (Hunt 1993). Stream channel excavation (trenching) with whole log covers and boulders, beaver dam removals, sediment traps, and rock-sill-and-gravel spawning riffles are recently evaluated techniques that are briefly defined and illustrated in the glossary beginning on page 81 accompanying this report.

Since 1985, numerous published and unpublished habitat evaluations have been completed in Wisconsin. These evaluations include: 1) studies in progress at the time of Hunt's (1988) compendium, 2) additional studies evaluating traditional and new habitat management techniques, 3) studies completed in new or poorly represented areas of Wisconsin, and 4) "follow-up" studies that provide longer term perspectives on previously reported habitat evaluations.

The goal of this study was to analyze these evaluations in an effort to fill in some of the distribution gaps in Hunt's (1988) compendium, to assess new habitat techniques, assist fisheries managers in their selection of appropriate development techniques, and to continue tracking the results achieved by this major fisheries management program.

[2] Does not include $0.14 handling fee per stamp per license outlet; does not include additional monies generated through the "Patron License".

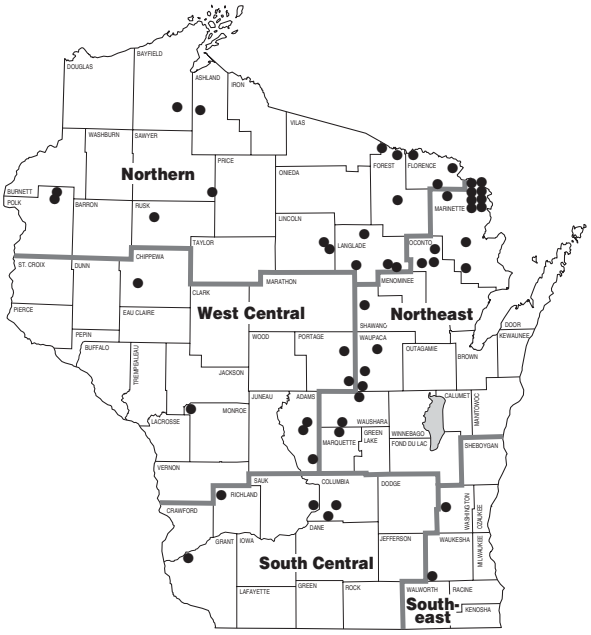


Figure 1. *Locations of 53 streams in 25 counties where trout habitat development projects were evaluated.*

Methods

Source Documents

In August 1999 a memorandum was distributed to 59 Wisconsin DNR fisheries managers, biologists, and technicians requesting them to provide copies of unpublished evaluations of trout habitat development projects done since 1985. Managers were encouraged to provide not only successful evaluations but also those that could be interpreted as "unsuccessful" or inconclusive. In addition, published reports were compiled that evaluated trout stream habitat development projects in Wisconsin.

Using a format similar to Hunt (1988)[3], case history summaries were prepared for 58 evaluations on 53 streams in 25 counties (Fig. 1). Biological and physical data were evaluated from a total of 64 treatment zones averaging 0.53 mile in length and 21 reference zones averaging 0.25 mile in length. The total length of all study zones was 39.1 miles. With the exception of the Mecan River (studied from1964-67), evaluations were carried out from1985-2000.

Source documents for the evaluations included 4 published reports, 8 internal Wisconsin DNR memos, 4 unpublished trout research files, and 13 personal communication memos. Several of the source documents provided information on more than one evaluation site or stream. All source documents are on file at the Rivers and Streams Research Headquarters, DNR, 11084 Stratton Lake Road, Waupaca WI 54981.

Investigators reported that trout population data were derived primarily from mark-recapture techniques using electrofishing gear. There were 3 case history exceptions; 1 treatment zone on the North Branch of the Prairie River, 2 treatment zones on McKenzie Creek, and 1 treatment zone on Wisconsin Creek. For these 3 exceptions, the principal investigators assumed similar electrofishing efficiencies for single-run inventories made before and after habitat development.

Data gathered from source documents encompassed a wide range of variables. In preparation for designing the compendium format and analyzing case history data, I categorized the source documents by:

1. **Stream classification[4]:**
   - Class I (36 streams, 45 treatment zones)
   - Class II (17 streams, 19 treatment zones)
2. **Fishing regulation or category that was in place when a post-treatment evaluation was completed[5]:**
   - Pre-1990 regulations [14 streams, 15 treatment zones (includes the 2 streams and 2 treatment zones affected by 1986 regulatory changes on southern Wisconsin streams)]
   - Post-1990 regulations[6]

     Category 1 (8 streams, 13 treatment zones)

     Category 2 (12 streams, 15 treatment zones)

     Category 3 (4 streams, 4 treatment zones)

     Category 4 (10 streams, 11 treatment zones)

     Category 5 (6 streams, 6 treatment zones)
3. **Trout species present:**
   - Wild brook trout (*Salvelinus fontinalis*) (19 streams, 25 treatment zones)
   - Wild brown trout (*Salmo trutta*) (8 streams, 9 treatment zones)
   - Wild brook and wild brown trout (15 streams, 18 treatment zones)
   - Wild and domestic brook trout (2 streams, 2 treatment zones)
   - Wild and domestic brown trout (2 streams, 2 treatment zones)

[3] I purposefully followed a similar format, with the author's permission, to facilitate comparisons between the two studies.

[4] Wisconsin DNR (1980).

[5] vis-à-vis Guide to Trout Fishing Regulations, Wisconsin DNR 1985-1989; Trout Fishing Regulations and Guide, Wisconsin DNR 1990-2000.

[6] In 1990 trout streams were placed in 1 of 5 regulation categories. See Table 2.

- Wild and domestic brook trout and wild brown trout (1 stream, 1 treatment zone)
- Wild and domestic brook trout and domestic brown trout (1 stream, 1 treatment zone)
- Wild and domestic brown trout and wild brook trout (2 streams, 2 treatment zones)
- Wild brook and wild brown trout and domestic rainbow trout (*Salmo gairdneri*) (1 stream, 1 treatment zone)
- Wild and domestic brook trout and wild and domestic brown trout (1 stream, 2 treatment zones)
- Wild and domestic brook trout, wild and domestic brown trout, and domestic rainbow trout (1 stream, 1 treatment zone)

4. Habitat development technique applied (see Table 1):

- Bank covers and current deflectors (19 streams, 21 treatment zones)
- Bank cover logs and current deflectors (3 streams, 3 treatment zones)
- Beaver dam removals (8 streams, 13 treatment zones)
- Channel excavation with whole log covers and boulders (4 streams, 6 treatment zones)
- Stream bank debrushing or brush bundles (2 streams, 2 treatment zones)
- Stream bank debrushing, brush bundles, and half-logs (3 streams, 3 treatment zones)
- Sediment trap or sediment trap with gravel spawning riffle (4 streams, 4 treatment zones)
- Riprap (3 streams, 3 treatment zones
- Other combinations of techniques (8 streams, 9 treatment zones)

5. Experimental design utilized:

- 21 designs based on data from reference zones and treatment zones, before and after development
- 39 designs based on data from treatment zones, before and after development
- 3 designs based on data from treatment zones, before and after development (single-run electrofishing surveys only)
- 1 design that provided data from a reference zone and treatment zone after development

Table 1. *Listing of habitat evaluation sites by stream name, county, and predominant type of development technique evaluated.*

Predominant Technique	Stream	County
Bank covers and current deflectors	Davis/Clayton Creek	Waushara
	E. Branch Eau Claire River	Langlade
	Elvoy Creek[a]	Forest
	Emmons Creek	Portage
	Evergreen River	Langlade
	First S. Branch Oconto River	Oconto
	Fordham Creek	Adams
	Hunting River	Langlade
	K.C. Creek	Marinette
	LaMontange Creek	Florence
	LePage Creek	Florence
	Little Roche A Cri Creek	Adams
	Mecan River	Waushara
	Murray Creek	Waupaca
	Neenah Creek	Adams
	N. Branch Beaver Creek	Marinette
	Prairie River	Lincoln
	Tomorrow River	Portage
	Waupaca River	Waupaca
Bank cover logs and current deflectors (high gradient)	Camp Creek	Richland
	Devils Creek	Rusk
	Twenty Mile Creek	Bayfield
Beaver dam removal	Brown Spur Creek	Marinette
	C & B Creek	Marinette
	E. Cataline Creek	Marinette
	Ernst Creek	Marinette
	Genricks Creek	Marinette
	Lost Creek	Marinette
	N. Branch Pemebonwon River	Marinette
	No Name Creek	Marinette
Channel excavation with whole log covers and boulders	Allen Creek	Forest
	Elvoy Creek[a]	Forest
	N. Branch Prairie River	Lincoln
	North Otter Creek	Forest
Streambank debrushing	Hay Creek	Oconto
	Little Evergreen Creek	Langlade
Streambank debrushing and half-logs with or without brush bundles	Clam River	Polk
	Paradise Spring Creek	Waukesha
	Price Creek	Sawyer
Sediment trap and/or gravel spawning riffle	Big (Cataract) Creek	Monroe
	Chaffee Creek	Marquette
	Hay Creek	Chippewa
	Waupee Creek	Oconto
Riprap	Lodi Creek	Columbia
	Millville Creek	Grant
	Rowan Creek	Columbia
Other Combinations[b]	Allenton Creek	Washington
	Manley Creek	Sauk
	McKenzie Creek	Polk
	Middle Branch Embarrass River	Shawano
	Middle Inlet Creek	Marinette
	Spring Brook	Ashland
	Whitcomb Creek	Waupaca
	Wisconsin Creek	Florence

[a] Listed twice. Two predominant techniques were evaluated at different sites on the same stream.

[b] Included in this category are various combinations of techniques where no technique was clearly dominant. See "Type of Development/ Enhancement" detailed in the individual case histories.

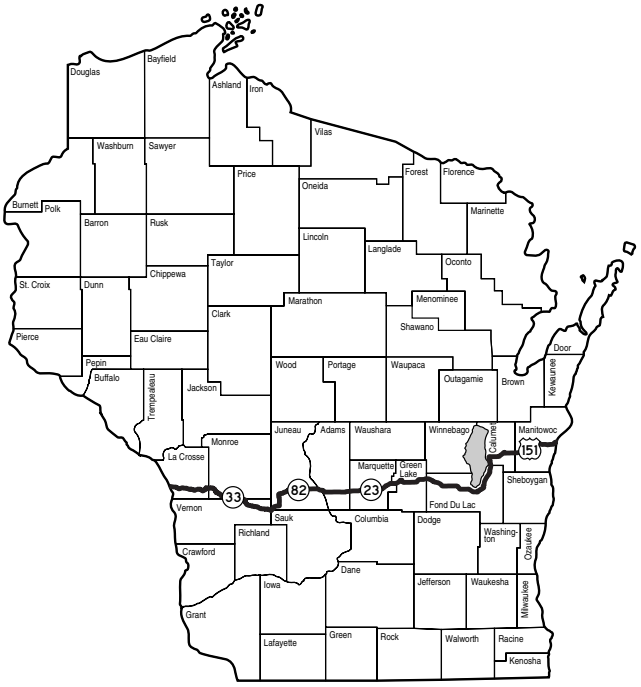


Figure 2. *The southern zone for trout water regulations includes all or portions of 28 southern Wisconsin counties south of highways 33, 82, 23, and 151.*

Variables Used to Measure Change

Four population variables were chosen for comparison and were standardized using the "per mile" unit of expression. No sport fishery variables were chosen since only 1 of 58 case histories provided sport fishery data. The 4 population variables most often included in the case histories were: 1) total number of trout, 2) number of trout >6 inches, 3) number of legal size trout, and 4) total biomass.

No case history provided information on all 4 variables. Two population variables (number of trout ≥6 inches and number of legal size trout) were equivalent in 11 case histories and, as a result, were counted only once as "number of legal size trout". Twenty-two case histories provided information on 3 of the 4 population variables.

A few case histories also included other indices of trout population changes, such as, number of age 0 trout per mile, number of age 1+ trout per mile, number of trout per mile ≥5 inches, etc. These less frequently used characteristics were not utilized in this compendium to assess success rates of projects.

In 1986, new fishing regulations took effect in southern Wisconsin. These regulations reduced the daily bag limit from 5 to 3 trout and increased the minimum legal size trout from 6 inches to 9 inches (Fig. 2). In 1990, a statewide change in fishing regulations took effect that placed all trout streams in 1 of 5 regulation categories and changed daily bag and legal size limits accordingly (Table 2). Therefore, the population variable "number of legal size trout" represents a wide range of size classes depending upon the regulation category in place on the individual stream (see individual case histories for details). In addition to the habitat development procedures applied, regulatory changes may have had some effect on the population variables examined in this study. However, for purposes of the evaluation presented in this report no distinctions were made.

Changes in one or more of the 4 trout population variables provided 140 usable values for analysis (Table 3). I used these values to analyze success of individual projects (see individual case histories for details) and the average success of various groupings of habitat development projects.

Table 2. *Trout fishing regulations.*

1986 (excluding Southern Zone) to 1989		
Season[a]	**Minimum Size Limit**	**Daily Bag Limit**
May	6 inches	10 (only 5 browns or rainbows in aggregate)
Jun - Sept 30	6 inches	10
Implemented Statewide in 1990		
Regulation Category	**Minimum Size Limit**	**Daily Bag Limit**
1	None	10 (only 5 browns or rainbows in aggregate)
2	7 inches	5
3	9 inches	3
4	Brown and rainbow trout-12 inches; Brook trout- 8 inches	3
5	Special regulations. Size and bag limits vary by specific water (see *Wisconsin Trout Fishing and Regulations Guide*).	

[a] Generally, trout fishing season begins the first Saturday in May and ends September 30th.

Table 3. *Number of values for each of 4 variables used to analyze overall success of habitat development projects.*

Variable	Number of Values	Number of Streams	Number of Treatment Zones
Total number of trout (all sizes)	58	49	58
Number of trout ≥6 inches	20	14	20
Number of legal-size trout	34	29	34
Total biomass (pounds per mile)	28	23	28

Criteria Used to Measure Success

No statistical testing was done with the trout population data included in this compendium beyond what was carried out originally by the principal investigators. I used the same arbitrary criteria of success selected by Hunt (1988) for each of the 4 standardized variables: Level 1= post-development increases in the population variable of 25% or more and Level 2= increases in the population variable of 50% or more. These arbitrary indices seem reasonable as acceptable long-term annual benefits from habitat manipulations made to remedy perceived deficiencies in trout carrying capacity. The case history collection provides the information needed to determine other criteria of success, should they be desired.

If the experimental design involved only pre-development vs. post-development measurements of a variable within a treatment zone, the post-development value (or average) for that variable was divided by the pre-development value (or average) to determine the percent change that occurred and the level of success.

If the experimental design included use of a treatment zone and a reference zone, and measurements of a variable were made in both zones *before and after* habitat development in the treatment zone, the post-development change in the treatment zone had to exceed the post-development change in the reference zone by 25% or 50% to qualify as success at Levels 1 and 2, respectively.

If the experimental design included use of a treatment zone and a reference zone, and measurements of a variable were made in both zones during the first and second years *after* habitat development, the post-development change in the treatment zone during the second year had to exceed the post-development change in the reference zone during the second year by 25% or 50% to qualify as success at Levels 1 and 2, respectively.

In 8 case histories, investigators also measured empirical changes in physical characteristics of their study zones. These changes are reviewed within the individual case history reports, but I did not summarize or use this documentation to judge success or failure of development projects.

Cost Analysis

A few of the published and unpublished case history documents provide information on financial expenditures to implement a habitat development project (see individual case histories for details). I did not attempt to summarize or interpret these costs in this compendium because of the inconsistency in what costs were and were not included in the development projects. A comprehensive technique-specific assessment of projects covering evaluations of the kind included in this compendium would be useful. However, as Hunt (1988) stated, "necessary prerequisites would include more consistent statewide procedures for cost accounting and agreement on what costs should be included in a development project".

Results and Discussion

Success of Habitat Development Projects

Among the 140 trout population variables analyzed, 59% reached the Level 1 success rate (i.e. 82 of 140 variables showed a post-development increase of 25% or more). Fifty percent reached the Level 2 success rate (Table 4). Success of individual habitat development projects, as measured by the 4 standardized variables, is indicated in the case history summary for each stream and is summarized in Appendix 1.

Success Rates by Stream Classification

Among the 64 treatment zones evaluated, 45 were on Class I streams. These 45 treatment zones provided 100 measurements in one or more of the 4 criteria selected to assess post-development success. Fifty-six percent of the post-development change reached Level 1 success; 48% reached Level 2 (Table 4).

Success rates were higher for projects initiated on Class II streams. Sixty-eight percent of the post-development change reached Level 1 success; 55% reached Level 2 (Table 4).

Table 4. *The success rates of 140 measurements of the 4 trout population variables derived from 64 habitat development projects. Level 1 (L1) success = 25% increase and Level 2 (L2) success = 50% increase.*

Stream Classification[a]	Number of Case History Evaluations	Number of Percent Change Measurements	Percent Successful	
			L1	L2
Class I	45	100	56[b]	48[b]
Class II	19	40	68	55
Combined	64	140	59	50

[a] Class I streams are high quality trout waters, having sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity. They require no stocking and are often small headwater streams. Class II streams are generally larger and have some natural reproduction but not enough to utilize all available food and space. Stocking is sometimes required (Wisconsin DNR 1980).

[b] Interpretation example: 56% of 100 percent change measurements showed at least a 25% increase in the treatment zone after habitat development; 48% of the 100 measurements showed at least a 50% increase.

Table 5. *Success rates for 4 trout population variables summarized by stream classification. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase.*

	Total Number of Trout per Mile			Number of Trout per Mile ≥6 Inches			Number of Legal-size Trout per Mile			Pounds of Trout per Mile		
		Percent Success			Percent Success			Percent Success			Percent Success	
Stream Classification[a]	Number Measured	L1	L2	Number Measured	L1	L2	Number Measured	L1	L2	Number Measured	L1	L2
I	42	40	31	16	88	81	23	61	57	19	58	47
II	16	50	31	4	75	75	11	73	73	9	89	67
Combined	58	43	31	20	85	80	34	65	62	28	68	54

[a] Class I streams are high quality trout waters, having sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity. They require no stocking. Class II streams are generally larger and have some natural reproduction but not enough to utilize all available food and space. Stocking is sometimes required (Wisconsin DNR 1980).

Success Rates by Variable

The 140 indices of success or failure are summarized for each of the 4 standardized variables and for the 2 classifications of trout streams (Table 5). Success rates at Levels 1 and 2 were equal to or higher for 3 of the 4 trout population variables in Class II streams.

For all projects reviewed, 43% of 58 measurements achieved Level 1 success for the change in total number of trout in the post-development treatment zone. Eighty-five percent of 20 measurements achieved Level 1 success for the change in total number of trout ≥6 inches, 65% of 34 measurements achieved Level 1 success for the change in total number of legal-size trout, and 68% of 28 measurements achieved Level 1 success for the change in pounds of trout present.

Success Rates by Fishing Regulations in Effect

The 140 indices of success or failure are summarized for each of the 4 standardized variables and for fishing regulations in effect before and after 1990 (Table 6). Success rates at Levels 1 and 2 were generally higher for the 4 trout population variables following implementation of the new fishing regulations in 1990. Regulatory changes may have had as great an effect on trout population parameters as the habitat development implemented. However, larger sample sizes (up to 20 times as many measurements per population variable) in the post-1990 era may also be responsible.

For projects reviewed during the post-1990 era, 46% of 48 measurements achieved Level 1 success for the change in total number of trout in the post-development treatment zone. Eighty-five percent of 20 measurements achieved Level 1 success for the change in total number of trout ≥6 inches, 78% of 23 measurements achieved Level 1 success for the change in total number of legal-size trout, and 63% of 19 measurements achieved Level 1 success for the change in pounds of trout present.

Success Rates by Trout Species

Eleven treatment zones contained mostly wild brown trout and 27 treatment zones held mostly wild brook trout. Habitat development was not consistently more beneficial to one species over another (Table 7). However, brook trout experienced higher success rates at Levels 1 and 2 than brown trout for the population variable “Total number of trout per mile”. Habitat development projects on brown trout streams were mostly successful at producing increased numbers of legal-size trout and increased biomass (measured in pounds of trout per mile). For all population variables combined, brook trout success slightly exceeded those of brown trout when in allopatry[7].

Success Rates in Treatment Zones with Wild Brook Trout and Wild Brown Trout

Twenty-three treatment zones receiving habitat development contained populations of wild brook and wild brown trout (Table 8). In those treatment zones, wild brown trout had greater success than wild brook trout. Level 1 success was achieved only 35% of the time in all population variables measured for brook trout. Sympatric[8] brown trout achieved Level 1 success 75% of time. Level 2 success for wild brook trout was achieved 31% of the time while co-existing wild brown trout achieved Level 2 success 58% of the time.

[7] Only one trout species present.
[8] One of two or more co-existing trout species present.

Table 6. *Success rates for the 4 trout population variables summarized by fishing regulation category. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase.*

Fishing Regulation Category[a]	Total Number of Trout per Mile			Number of Trout per Mile ≥6 Inches			Number of Legal-size Trout per Mile			Pounds of Trout per Mile			All Variables		
	Number Measured	Percent Success L1	L2	Number Measured	Percent Success L1	L2	Number Measured	Percent Success L1	L2	Number Measured	Percent Success L1	L2	Number Measured	Percent Success L1	L2
Pre-1990	11	27	9	0	0	0	11	36	36	8	88	38	30	47	27
Post-1990															
Category 1	13	92	85	12	83	83	0	0	0	1	0	0	26	85	81
Category 2	15	20	7	1	0	0	10	70	60	6	50	50	32	41	31
Category 3[b]	5	20	20	3	100	100	1	100	100	1	100	100	10	60	60
Category 4	9	33	22	2	100	50	10	90	90	8	62	62	29	66	59
Category 5	6	50	33	2	100	50	2	50	50	3	100	100	13	69	54
Post-1990 Subtotals	48	46	35	20	85	75	23	78	74	19	63	63	110	63	55

[a] Prior to 1990, fishing regulations on inland trout waters were a minimum size limit of of 6 inches and a daily bag limit of either 5 or 10 fish. In 1986, a size limit of 9 inches and a bag limit of 3 fish was established in a southern Wisconsin DNR trout zone and beginning in 1990, all trout streams were placed in one of 5 different regulation categories.

[b] Includes 5 measurements on 2 streams in southern Wisconsin under pre-1990 regulations that are equivalent to Category 3.

Table 7. *Success rates for the 4 trout population variables summarized for wild brook trout and wild brown trout. Data shown are from treatment zones (TZ) where only 1 of the 2 species was present during the evaluations. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase.*

Trout Species	Number of Treatment Zones	Total Number of Trout per Mile			Number of Trout per Mile ≥6 Inches			Number of Legal-size Trout per Mile			Pounds of Trout per Mile			All Variables		
		Number Measured	Percent Success L1	L2	Number Measured	Percent Success L1	L2	Number Measured	Percent Success L1	L2	Number Measured	Percent Success L1	L2	Number Measured	Percent Success L1	L2
Brook	27[a]	27	63	52	1	100	100	10	50	50	6	67	67	44	61	55
Brown	11[b]	11	45	27	1	100	100	5	60	60	2	100	100	19	58	47

[a] Includes Big Creek and North Branch Pemebonwon River which contained both wild and stocked brook trout.

[b] Includes Chaffee and Millville Creeks which contained both wild and stocked brown trout.

Table 8. *Success rates for the 4 trout population variables summarized for wild brook trout, wild brown trout, and both species combined. Data shown are from 23 treatment zones (TZ) where both species were present during the evaluations. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase.*

Fishing Regulation Category[a]	Total Number of Trout per Mile: Number Measured	Percent Success L1	Percent Success L2	Number of Trout per Mile ≥6 Inches: Number Measured	Percent Success L1	Percent Success L2	Number of Legal-size Trout per Mile: Number Measured	Percent Success L1	Percent Success L2	Pounds of Trout per Mile: Number Measured	Percent Success L1	Percent Success L2	All Variables: Number Measured	Percent Success L1	Percent Success L2
Brook	19[a]	21	21	3	67	0	17[b]	59	59	16[b]	19	19	55	35	31
Brown	19[a]	47	37	3	100	67	17[b]	94	71	16[b]	81	69	55	75	58
Combined	19[a]	21	21	3	67	67	17[b]	71	65	16[b]	69	44	55	53	44

[a] Includes Hay Creek and the Waupaca River which both contained wild brook and wild and domestic brown trout; also includes Waupee Creek which contained wild and domestic brook trout and wild brown trout.

[b] Includes the Hunting River which contained wild and domestic brook trout and wild brown trout.

Success Rates by Development Type

Table 9 provides success rates for 4 trout population variables categorized by the predominant type of habitat development. The bank cover and current deflector technique that was pioneered in Wisconsin to improve trout habitat produced good results. A total of 50 measurements of the 4 population variables were determined on the 19 streams where the bank cover and current deflector technique was featured. Level 1 success was achieved 56% of the time and Level 2 success was achieved 46% of the time. Development projects where the bank cover and current deflector technique were used was slightly more successful in Class II streams as opposed to Class I streams (Table 9).

Beaver dam removals resulted in the highest success rates achieved by any type of habitat development. A total of 26 measurements of the 4 population variables were determined on the 8 streams where beaver dam removal occurred. Level 1 success was achieved 92% of the time and Level 2 success was achieved 85% of the time (Table 9). Development projects of this type were mainly watershed oriented and included intensive removal of beaver as well as annual maintenance to preserve free flowing conditions.

The bank cover log and current deflector technique was specifically targeted to higher gradient (1-3%) streams in Wisconsin. Development projects of this type were evaluated on 3 streams and produced an additional 9 measurements of the 4 population variables. Success at Levels 1 and 2 was achieved 78% and 44% of the time, respectively (Table 9).

Two commonly used techniques, stream bank debrushing and stream bank debrushing and half-logs with or without brush bundles, produced disappointing results based upon 11 measurements from 5 streams (Table 9). When combining the two techniques, Level 1 and 2 success was achieved only 9% of the time.

Construction of a sediment trap or sediment trap and gravel spawning riffle proved disappointing. There were no Level 1 successes in any of the 5 measurements of the 4 population variables. According to the case histories, all 4 treatment zones were selected to test these habitat development techniques under worst case scenarios (i.e. situations where both gravel substrate and natural reproduction was absent). However, documented successes in Michigan trout streams and two qualified successes reported by Wisconsin fisheries managers (see individual case histories) suggest these techniques do have merit in the correct situation.

Table 10 provides a more detailed analysis of success rates categorized by both the predominant type of habitat development and by trout species present. This table highlights the differences in success rates for wild brook trout in the presence and absence of wild brown trout. In treatment zones containing *only* wild brook trout (allopatry) and where the type of habitat development was channel excavation with whole log cover and boulders, Levels 1 and 2 success were achieved 63% of the time (Table 10). In treatment zones where the same habitat development was done, but where wild brook trout and wild brown trout were *both* present (sympatry), Levels 1 and 2 success were achieved for brook trout only 38% of the time. However, in the same treatment zones for brown trout, Levels 1 and 2 success were achieved 63% of the time.

In treatment zones containing *only* wild brook trout for all types of habitat improvement, Level 2 success was achieved 62% of the time.

In treatment zones containing *both* wild brook trout and wild brown trout for all types of habitat development Level 2 success was achieved 35% of the time for wild brook trout (Table 10). In the same treatment zones, however, wild brown trout exhibited Level 2 success 69% of the time.

Superior performance of wild brown trout in sympatry with wild brook trout was also documented in Hunt's (1988) compendium of habitat evaluations in Wisconsin. "Superior performance by wild brown trout in sympatry with wild brook trout is probably a reflection of at least 2 factors: 1) direct interspecific competition in which brown trout dominate and occupy the best habitat niches available (Fausch and White 1981, Waters 1981) and 2) greater angler exploitation of brook trout (Avery 1983)". Unfortunately, from the perspective of the Wisconsin DNR trout management philosophy that stresses more attention to management of brook trout because of its endemic status, neither the habitat development techniques evaluated by Hunt (1988) nor current habitat development techniques appear to favor brook trout over brown trout in sympatric situations. Until enhancement techniques favoring brook trout in sympatry with brown trout are discovered, species-specific angling regulations that provide protection for brook trout or physical removal of brown trout are better alternatives than stopping habitat development in streams holding both brook and brown trout.

Success Rates in Long-term Comparisons

Long-term comparisons of the success of habitat development projects that were demonstrated by Hunt (1988) were possible in only 6 treatment zones on 5 streams in the current study (Table 11). Overall, success rates for all 5 streams combined were poorer at Levels 1 and 2 over the long term than when initially reported. However, it should be noted that the small sample size, different species present, and varying types of habitat development examined might have affected the overall conclusions. Individual case histories should be consulted for more specific information on long-term success.

Empirical Changes in Trout Population Variables

When examining the population variable "total number of trout per mile" in 27 treatment zones, the average post-development density for brook trout of all sizes increased by 14% (Table 12). The average post-development density of brook trout ≥6 inches increased by 69% in 15 treatment zones, and the average number of legal-size brook trout increased 17% in 10 treatment zones. In 6 treatment zones, the

Table 9. *Success rates of all the trout population variables combined summarized by the predominant type of habitat development applied in the treatment zones (TZ) and by stream class. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase.*

Predominant Type of Habitat Development	Number Measured	Percent Success	
		L1	L2
Bank covers and current deflectors			
Class I[a]	36	50	42
Class II	14	71	57
Combined	50	56	46
Beaver dam removals			
Class I	24	92	88
Class II	2	100	50
Combined	26	92	85
Channel excavation with whole log covers and boulders			
Class I	8	38	25
Class II	8	75	75
Combined	16	56	50
Bank cover logs and current deflectors (high gradient)			
Class I	6	67	50
Class II	3	100	33
Combined	9	78	44
Stream bank debrushing			
Class I	6	0	0
Class II	0	0	0
Combined	6	0	0
Stream bank debrushing, half-logs, with or without brush bundles			
Class I	5	20	20
Class II	0	0	0
Combined	5	20	20
Sediment trap or sediment trap and gravel spawning riffle			
Class I	1	0	0
Class II	4	0	0
Combined	5	0	0
Riprap			
Class I	0	0	0
Class II	7	57	57
Combined	7	57	57
Other combinations[b]			
Class I	14	57	43
Class II	2	100	100
Combined	16	63	50

[a] Class I streams are high quality trout waters having sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity. They require no stocking and are often small headwater streams. Class II streams are generally larger and have some natural reproduction but not enough to utilize all available food and space. Stocking is sometimes required (Wisconsin DNR 1980).

[b] Included in this category are various combinations of techniques where no technique was clearly dominant. See "Type of Development/Enhancement" detailed in the individual case histories.

Table 10. *Success rates for all the trout population variables combined[a] summarized by the type of habitat development applied in the treatment zones (TZ) and the trout species present. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase.*

	Bank Cover and Current Deflectors			Bank Cover Logs and Current Deflectors			Beaver Dam Removals			Channel Excavation with Whole Log Covers and Boulders		
		Percent Success			Percent Success			Percent Success			Percent Success	
Trout Species	Number Measured	L1	L2	Number Measured	L1	L2	Number Measured	L1	L2	Number Measured	L1	L2
One species present:												
Wild brook	2	0	0				24	92	88	8	63	63
Wild brown	6	17	0	3	67	67						
Wild brook												
Domestic brook												
Combined[c]							2	100	50			
Wild brown												
Domestic brown												
Combined[c]												
Two species present:												
Wild brook	31	39	35	3	67	33				8	38	38
Wild brown	31	77	71	3	100	67				8	63	63
Combined	31	61	55	3	67	33				8	50	38
Wild brook[c]												
Domestic brook												
Wild brown												
Combined												
Wild brook[c]				3	0	0						
Domestic brook												
Domestic brown				3	100	100						
Combined				3	100	33						
Wild brook	1	0	0									
Wild brown[c]	1	0	0									
Domestic brown												
Combined	1	0	0									
Wild brook[c]	4	0	0									
Domestic brook												
Wild brown[c]	4	100	50									
Domestic brown												
Combined	4	50	25									
Three species present:												
Wild brook	3	100	67									
Wild brown	3	100	100									
Domestic rainbow	2[d]	100	0									
Combined	3	100	67									
Wild brook[c]	2	100	100									
Domestic brook												
Wild brown[c]	2	100	100									
Domestic brown												
Domestic rainbow	0	No Data During Post-Treatment										
Combined	2	100	100									

[a] The population variables measured were: total no. trout, no. ≥6 inches, no. legal-size, and total biomass.

[b] Included in this category are various combinations of techniques where no technique was clearly dominant. See "Type of Development/Enhancement" detailed in the individual case histories.

[c] Wild and domestic trout of the same species are combined in the original data; a third measurement (biomass) was not recorded during all 5 post-treatment years and is not included.

[d] Data for the 3rd measurement for rainbow trout was not recorded during post-treatment.

Streambank Debrushing and/or Brush Bundles			Streambank Debrushing, Brush Bundles and Half-logs			Sediment Trap and/or Gravel Spawning Riffle			Riprap			Other Combinations[b]			All Structure Types		
	Percent Success			Percent Success			Percent Success			Percent Success			Percent Success			Percent Success	
Number Measured	L1	L2	Number Measured	L1	L2	Number Measured	L1	L2	Number Measured	L1	L2	Number Measured	L1	L2	Number Measured	L1	L2
3	0	0	2	0	0							14	57	50	53	66	62
									4	25	25	2	100	50	15	40	27
						2	0	0							4	50	25
						1	0	0	3	100	100				4	75	75
3	0	0	3	67	67										48	40	35
3	100	100	3	67	33										48	77	69
3	0	0	3	33	33										48	54	46
						1	0	0							1	0	0
						1	0	0							1	0	0
						1	0	0							1	0	0
															3	0	0
															3	100	100
															3	100	33
						1	0	0							2	0	0
						1	0	0							2	0	0
						1	0	0							2	0	0
															4	0	0
															4	100	50
															4	50	25
															3	100	67
															3	100	100
															2	100	0
															3	100	67
															2	100	100
															2	100	100
															2	100	100

average post-development biomass of brook trout (pounds of trout per mile) was 66% greater than the pre-development biomass (121 pounds per mile vs. 73 pounds per mile; Table 12).

In 9 treatment zones holding brown trout, the average post-development density (number of trout per mile) for trout of all sizes declined by 29%. The number of brown trout ≥6 inches increased 74% in 1 treatment zone, but the number of legal-sized brown trout declined 41% in 5 treatment zones. The average post-development biomass of brown trout increased 116% in 2 treatment zones (Table 12).

In 20 treatment zones holding sympatric stocks of brook and brown trout of all sizes, the average abundance of trout (number per mile) decreased 22% (Table 12). The average abundance of combined brook and brown trout ≥6 inches increased 63% in 3 treatment zones; the number of legal-sized trout

Table 11. *Listing of long-term case history streams comparing the predominant habitat development type employed, number of population variables measured, and both the short-term and long-term percentage success rates at two levels of success. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase.*

Stream	County	Trout Species Present	Number of Treatment Zones	Predominate Type of Habitat Development	Number of Population Variables	Short Term Success		Long Term Success	
						L1	L2	L1	L2
Hay Creek	Oconto	Brook	1	debrushing	2[a]	0	0	0	0
Hunting River	Langlade	Brook & Brown	1	bank covers and current deflectors	2	100	100	50	50
Hunting River	Langlade	Brook & Brown	2	bank covers and current deflectors	2	100	50	50	0
K.C. Creek	Marinette	Brook & Brown	1	other combinations	2[a]	0	0	0	0
Middle Branch Embarrass River	Shawano	Brook	1	other combinations	1[a]	0	0	0	0
Prairie River	Lincoln	Brook & Brown	1	bank covers and current deflectors	2[a]	50	50	100	50
Overall Success					11	45	36	36	18

[a] Although 1 or 2 additional population variables were provided in the long-term case histories, the same variables were compared for both the short-term and long-term evaluations.

Table 12. *Average values for the 4 wild trout population characteristics before (pre-) and after (post-) habitat development and the percent change in those values after development. N/A = no data available.*

Trout Species	Number of Streams	Number of Treatment Zones	Length of Treatment Zones (miles)	Total Number of Trout per Mile			Number of Streams	Number of Treatment Zones	Length of Treatment Zones (miles)	Number of Trout per Mile ≥6 Inches		
				Pre-	Post-	Percent Change				Pre-	Post-	Percent Change
Brook	21[a]	27	10.4	658	751	14	10[b]	15	2.2	55	93	69
Brown	9[d]	9	5.3	1,378	974	-29	1	1	0.4	375	651	74
Brook and brown												
Brook	18[e]	20	8.7	1,566	1,231	-21	2	3	0.9	556	697	25
Brown	18[e]	20	8.7	631	476	-25	2	3	0.9	364	800	120
Combined	18[e]	20	8.7	2,197	1,707	-22	2	3	0.9	920	1,497	63
Brook, brown, and domestic rainbow												
Brook	2	2	0.6	1,227	1,694	38						
Brown	2	2	0.6	52	141	171						
Rainbow	2	2	0.6	41	58	41						
Combined	2	2	0.6	1,320	1,893	43						

[a] Includes 2 streams (2 treatment zones) where stocked trout were present (Big Creek; North Branch Pemebonwon River).
[b] Includes 1 stream (1 treatment zone) where stocked trout were present (Big Creek).
[c] Includes 1 stream (1 treatment zone) where stocked trout were present (North Branch Pemebonwon River).
[d] Includes 2 streams (2 treatment zones) where stocked trout were present (Chaffee and Millville Creeks).
[e] Includes 4 streams (4 treatment zones) where stocked trout were present (Devils, Hay, and Waupee Creeks; Waupaca River).
[f] Includes 2 streams (3 treatment zones) where stocked trout were present (Devils Creek; Hunting River).

showed a 100% increase in 18 treatment zones, and the average post-development biomass increased 55% in 17 treatment zones (Table 12).

When examining all 58 treatment zones where trout abundance was measured (Table 12), the average post-development abundance of trout declined 13%. All trout ≥6 inches increased 65% in 19 treatment zones (3.5 miles). The average post-development increase in the number of legal-size trout was 25% in 35 treatment zones (18 miles) and trout biomass increased 63% in 26 treatment zones (Table 12).

Empirical summaries for wild brook trout populations are arranged by the type of habitat development applied (Table 13). Thirteen treatment zones featured beaver dam removals, 7 treatment zones included a variety of habitat combinations, 3 treatment zones featured channel excavation with whole log covers and boulders, 2 treatment zones featured stream bank debrushing, brush bundles or half-logs, and 1 treatment zone featured bank covers and current deflectors.

Removal of beaver dams had a positive effect on brook trout populations. The average number of brook trout per mile increased 191% in 13 treatment zones; brook trout ≥6 inches increased 283% in 12 treatment zones, and the average abundance of legal-size trout increased 70% (Table 13).

The use of bank cover and current deflectors produced a 33% improvement in the number of brook trout per mile and in 1 treatment zone was responsible for a 61% post-development increase in brook trout biomass (Table 13). In response to channel excavation with whole log covers and boulders, the average abundance of legal-size brook trout increased 200% and the average biomass increased 89% (Table 13); however, the total abundance of all sizes of brook trout declined 14%.

In treatment zones where other combinations of techniques were used, modest increases in the 4 population variables occurred (Table 13). Stream bank debrushing projects and stream bank debrushing and half-logs with or without brush bundles projects resulted in either status quo or negative brook trout population responses (Table 13).

Quantitative changes in wild brown trout populations are arranged by the type of habitat development applied (Table 14). For trout of all sizes, 3 treatment zones featured bank cover/current deflectors, 1 treatment zone included bank cover logs/current deflectors, 3 treatment zones featured riprap, 1 treatment zone included a sediment trap and gravel spawning riffle, and 1 treatment zone featured other combinations of habitat improvement.

Four of the 5 kinds of habitat development techniques, for the most part, were associated with

Number of Streams	Number of Treatment Zones	Length of Treatment Zones (miles)	Number of Legal-size Trout per Mile			Number of Streams	Number of Treatment Zones	Length of Treatment Zones (miles)	Pounds of Trout per Mile		
			Pre-	Post-	Percent Change				Pre-	Post-	Percent Change
9[c]	10	7.4	216	252	17	5	6	2	73	121	66
5	5	3.3	667	394	-41	2	2	2.2	68	147	116
14[f]	18	6.7	111	166	50	13[e]	17	5.9	66	65	-2
14[f]	18	6.7	44	143	225	13[e]	17	5.9	50	115	130
14[f]	18	6.7	155	309	100	13[e]	17	5.9	116	180	55
2	2	0.6	1,772	2,413	36	1	1	0.2	33	65	97
2	2	0.6	57	178	212	1	1	0.2	18	96	433
2	2	0.6	55	75	36	1	1	0.2	N/A	N/A	N/A
2	2	0.6	1,884	2,666	42	1	1	0.2	51	161	216

Table 13. *Average values for individual wild brook trout population characteristics before (pre-) and after (post-) habitat development summarized by the predominant type of habitat development applied.*

Predominant Type of Habitat Development	Number of Treatment Zones	Length of Treatment Zones (miles)	Total Number of Trout per Mile			Number of Treatment Zones	Length of Treatment Zones (miles)	Number of Trout per Mile ≥6 Inches		
			Pre-	Post-	Percent Change			Pre-	Post-	Percent Change
Bank covers/ current deflectors	1	0.3	483	644	33					
Beaver dam removals	13[a]	3.9	102	297	191	12	1.2	12	46	283
Channel excavation with whole log covers and boulders	3	1.2	2,404	2,073	-14					
Stream bank debrushing and/or half-logs and/or brush bundles	2	1.2	1,086	802	-26					
Other combinations[d]	7[b]	3.4	765	889	16	3[c]	1	225	282	25

[a] Includes 1 treatment zone (North Branch Pemebonwon River) that contained some stocked trout.

[b] Includes 1 treatment zone (Big Creek) that contained some stocked trout.

[c] Includes 1 treatment zone (Big Creek) that contained some stocked trout and 1 treatment zone (Manley Creek) represented only in this table.

[d] Included in this category are various combinations of techniques where no technique was clearly dominant. See "Type of Development/Enhancement" detailed in the individual case histories.

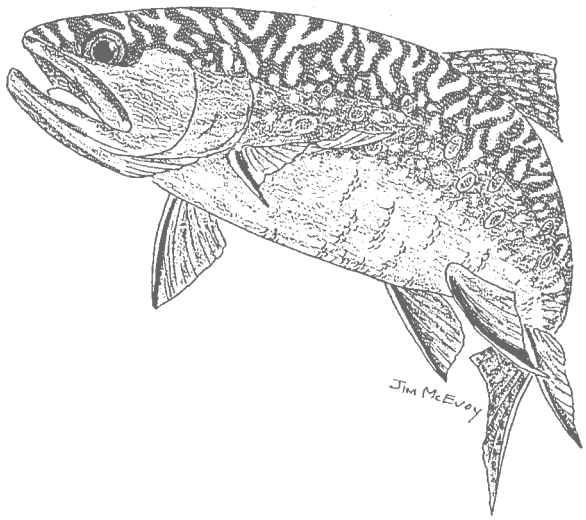
Table 14. *Average values for wild brown trout population characteristics before (pre-) and after (post-) habitat development summarized by the predominant type of habitat development.*

Predominant Type of Habitat Development	Number of Treatment Zones	Length of Treatment Zones (miles)	Total Number of Trout per Mile			Number of Treatment Zones	Length of Treatment Zones (miles)	Number of Trout per Mile ≥6 Inches		
			Pre-	Post-	Percent Change			Pre-	Post-	Percent Change
Bank covers/ current deflectors	3	1.2	2,920	1,501	-49					
Bank cover log/ current deflectors	1	0.2	490	1,819	271					
Sediment trap and gravel spawning riffle	1[a]	1	829	940	13					
Riprap	3[b]	2.8	669	346	-48	1	0.4	375	651	74
Other combinations[c]	1	0.2	313	468	50					

[a] The treatment zone in Chaffee Creek included some stocked trout.

[b] Includes 1 treatment zone in Millville Creek that included some stocked trout.

[c] Included in this category are various combinations of techniques where no technique was clearly dominant. See Type of Development/Enhancement detailed in the individual case histories.



Number of Treatment Zones	Length of Treatment Zones (miles)	Number of Legal-size Trout per Mile			Number of Treatment Zones	Length of Treatment Zones (miles)	Pounds of Trout per Mile		
		Pre-	Post-	Percent Change			Pre-	Post-	Percent Change
					1	0.3	36	58	61
1[a]	2.7	61	104	70					
2	0.5	98	294	200	3	1.2	73	138	89
2	1.2	486	329	-32	1	0.2	60	61	0
5	2.7	187	233	25	1	0.5	122	194	59

Number of Treatment Zones	Length of Treatment Zones (miles)	Number of Legal-size Trout per Mile			Number of Treatment Zones	Length of Treatment Zones (miles)	Pounds of Trout per Mile		
		Pre-	Post-	Percent Change			Pre-	Post-	Percent Change
2	0.8	1,554	787	-49					
1	0.2	208	330	59	1	0.2	123	267	117
2[b]	2.4	10	22	120	1[b]	2	13	27	108

positive changes in post-development abundance of brown trout (Table 14). The bank cover/current deflector technique resulted in negative changes in average total abundance and average number of legal-size trout present and was the exception. The most impressive gains occurred in the treatment zone where bank cover logs and current deflectors were installed. In that treatment zone there was an average 271% increase in the total number of brown trout per mile, an average 59% increase in legal-size trout per mile, and an average 117% increase in total biomass (pounds of trout per mile) (Table 14).

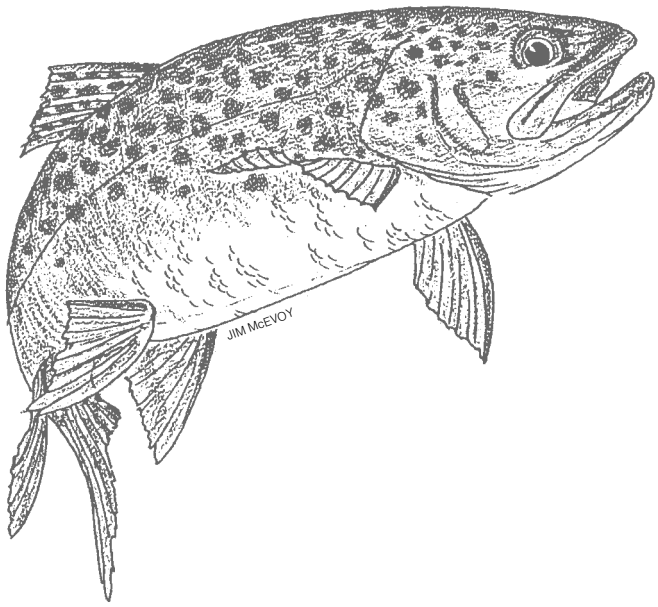
Empirical changes in sympatric (mixed) populations of wild brook and brown trout are arranged by the type of development applied to improve trout habitat (Table 15). Fourteen treatment zones featured bank cover and current deflectors, 2 treatment zones featured bank cover logs and current deflectors, 3 treatment zones included stream channel excavation with whole log covers and boulders, 2 treatment zones featured either a sediment trap or a sediment trap and gravel spawning riffle (Table 15).

The average post-development abundance of brook trout in 10 of 14 treatment zones receiving bank cover/current deflectors declined 29%, whereas the post-development abundance of brown trout in the same treatment zones declined by only 7%. When combining both species, there was an average decline in the total number of trout per mile of 21% (Table 15).

Table 15. *Average values for sympatric brook trout/ brown trout population characteristics before (pre-) and after (post-) habitat development summarized by the predominant type of habitat development.*

Predominant Type of Habitat Development	Number of Treatment Zones	Length of Treatment Zones (miles)	Total Number of Trout per Mile			Number of Treatment Zones	Length of Treatment Zones (miles)	Number of Trout per Mile ≥6 Inches		
			Pre-	Post-	Percent Change			Pre-	Post-	Percent Change
Bank covers/ current deflectors										
Brook	10[a]	4.3	1,311	934	-29	3[b]	0.9	556	697	25
Brown	10[a]	4.3	767	712	-7	3[b]	0.9	364	800	120
Combined	10[a]	4.3	2,078	1,646	-21	3[b]	0.9	920	1,497	63
Bank cover log/ current deflectors										
Brook	2	0.2	958	736	-23					
Brown	2	0.2	158	145	-8					
Combined	2	0.2	1,116	881	-21					
Channel excavation with whole logs and boulders										
Brook	3	1	4,506	3,644	-19					
Brown	3	1	1,165	334	-71					
Combined	3	1	5,671	3,978	-30					
Stream bank debrushing and/or brush bundles and/or half-logs										
Brook	3	1	810	737	-9					
Brown	3	1	198	267	35					
Combined	3	1	1,008	1,004	0					
Sediment trap and/or gravel spawning riffle										
Brook	2[d]	2.1	167	286	71					
Brown	2[d]	2.1	276	153	-45					
Combined	2[d]	2.1	443	439	-1					

[a] Includes 1 treatment zone (Waupaca River) that contained some stocked trout.
[b] Includes 2 additional treatment zones (Prairie River; 0.5 mile).
[c] Includes 2 additional treatment zones (Hunting River; 1.2 miles) that also contained some stocked trout.
[d] Both treatment zones (Hay and Waupee Creeks) contained some stocked trout.



Number of Treatment Zones	Length of Treatment Zones (miles)	Number of Legal-size Trout per Mile			Number of Treatment Zones	Length of Treatment Zones (miles)	Pounds of Trout per Mile		
		Pre-	Post-	Percent Change			Pre-	Post-	Percent Change
12[c]		116	187	16	11	4.4	66	61	-6
12[c]	4.9	56	189	238	11	4.4	57	148	160
12[c]	4.9	172	376	119	11	4.4	123	209	70
2	0.2	64	145	128	2	0.2	27	33	22
2	0.2	31	51	64	2	0.2	9	13	44
2	0.2	95	197	107	2	0.2	36	46	28
3	1	92	141	53	2	0.7	123	118	4
3	1	11	34	209	2	0.7	27	36	33
3	1	103	174	70	2	0.7	150	154	3
1	0.5	240	138	-42	2	0.6	50	66	32
1	0.5	28	119	325	2	0.6	75	118	57
1	0.5	268	257	-4	2	0.6	125	184	47

For legal-size trout in 12 treatment zones receiving bank cover/current deflectors, the opposite was true. The average post-development abundance of legal-size brook trout increased 16% and the average abundance of legal-size brown trout increased 238%! When combining both species, there was an average post-development improvement of 119% (Table 15).

Management Application and Implications

This compendium includes 58 case histories documenting the impacts of habitat development projects on Wisconsin's trout streams. Excluding the 6 case histories outlining long-term follow-up evaluations of habitat development projects previously reported, 52 new case histories are consolidated in this report (including 46 previously unpublished evaluations). On a statewide basis, these 52 case histories not only include evaluations on 41 new trout streams, but also include evaluations in 6 Wisconsin counties not previously represented. Although little mention is made of individual case histories in the results portion of this compendium, I encourage readers to examine the individual case history summaries for more specific information.

Consolidation with Previous Habitat Development Evaluations

To maximize the usefulness of this compendium as well as Hunt's (1988) compendium, I consolidated elements of both data sets to provide a summary of the consequences of habitat development on 82 different trout streams in 36 Wisconsin counties (see Fig. 3 and Appendix 1 and 2). This summary will guide fishery managers contemplating application of a habitat development technique, by directing them to all available case histories for a similar application or physically similar stream in their particular region of the state, and hopefully point them to the type of results they can expect.

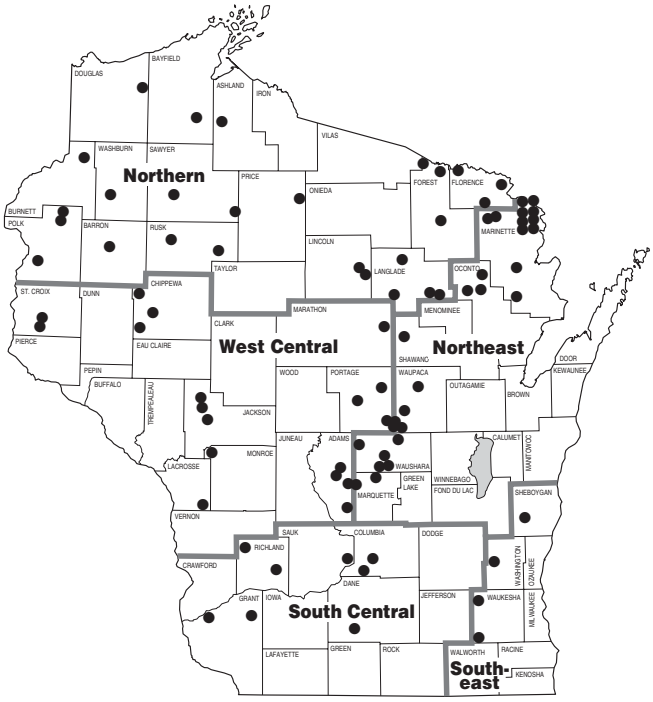


Figure 3. *Locations of 82 streams in 5 Wisconsin regions (Northern, Northeast, Southeast, South Central, and West Central) where trout habitat development projects were evaluated. Please note that Emmons Creek is represented twice in both Portage and Waupaca counties and Lawrence Creek is also represented twice in Adams and Marquette counties.*

Summarizing the case histories by Wisconsin DNR region yielded the following:

Region	No. Case Histories	No. Streams
Northern	38	26
Northeast	31	27
West Central	20	17
South Central	9	8
Southeast	5	4
Totals	103	82[9]

Using the 4 population variables and the two levels of success outlined in the present study, 103 case histories were compared providing an analysis of 244 trout population variables. The percent change after development was great enough to reach Level 1 success 59% of the time (i.e. 144 of the 244 indices improved by at least 25%). The rate of success at Level 2 was 49% (i.e. 120 of the 244 indices improved by at least 50%).

To assist fishery managers in choosing which development technique may be successful in their locale, I segregated the case histories of each habitat development type by DNR administrative region

Table 16. *Success of habitat development types categorized by region (See Fig. 3 for map of regions). Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase.*

Predominant Type of Habitat Development	Region[a]	Number of Streams	Number of Values	Percent Success L1	Percent Success L2
Bank cover/ current deflector	N	9[b]	30	67	60
	NE	9	22	68	59
	WC	6[b]	15	80	67
	SC	1	2	0	0
Bank cover log/ current deflector	N	2	6	83	33
	SC	1	3	67	67
Beaver dam removal	NE	8[b]	26	92	85
Channel excavation/ whole log cover/ boulders	N	4[b]	16	56	50
Streambank debrushing/ brush bundles/ half-logs	N	6[b]	15	20	20
	NE	3[b]	12	50	8
	WC	5	17	41	35
	SE	2	4	50	50
Sediment trap/ gravel spawning riffle	NE	2	2	0	0
	WC	2	3	0	0
Half-logs	NE	2	6	50	50
Riprap	SC	5	9	56	44
Other combinations[c]:	N	7[b]	19	68	42
	NE	4	11	18	18
	WC	5[b]	15	33	20
	SC	2	3	100	100
	SE	3	8	100	100

[a] N = Northern, NE = Northeast, WC = West Central, SC = South Central, SE = Southeast.
[b] Includes multiple treatment zones on one or more streams.
[c] Included in this category are various combinations of techniques where no technique was clearly dominant. See "Type of Development/Enhancement" detailed in the individual case histories.

(Table 16). Successful widespread application of 3 types of habitat development was apparent. The "bank cover/current deflector" habitat development in the N, NE, and WC regions achieved Level 1 success rates ranging from 67-80% and Level 2 success rates ranging from 59-67%. Although this type of habitat improvement is the most expensive, it provides trout population benefits for at least 30 years.

The "other combinations" category of habitat development was highly successful in the SE, SC, and N regions. Level 1 success rates for these 3 regions

[9] Includes 20 streams on which multiple evaluations were made.

ranged from 68-100% and Level 2 success rates ranged from 42- 100% (Table 16). This may be due to the fact that the "bank cover/current deflector" habitat development was almost always included in the "other combinations" category of habitat development type.

The habitat development of "stream bank debrushing alone or in conjunction with half-logs and/or brush bundles" acheived good success in the NE, WC, and SE regions. Level 1 success rates in these three regions ranged from 41-50% (Table 16). This particular habitat development technique involves no heavy equipment, minimum training, and is one of the quickest and least expensive techniques to apply. As a result, this technique is an excellent choice for use in cooperation with local conservation groups that can provide most of the labor.

Several types of habitat development are more regionally specific in their use but can achieve excellent success. The "bank cover log and current deflector" habitat development technique is specific to high gradient streams (1-3%) in Wisconsin. In the N and SC regions Level 1 success ranged from 67-83% (Table 16). "Beaver dam removal" achieved a Level 1 success of 92% in the NE region and is the most cost-effective technique for use in the northern-half of Wisconsin. The habitat development technique of using "Riprap" is primarily for riparian erosion control but increased standing stocks of trout in the SC region (Table 16). However, it should be noted that this technique treats a symptom rather than the cause of poor watershed management and may exacerbate problems further downstream. Using the "Half-logs" technique is inexpensive and excellent for use where overhead cover for larger trout is lacking. Currently, "half-logs" are generally used in combination with other types of habitat development.

Summary

Habitat development was not consistently more beneficial to either brook trout or brown trout in allopatry. Using all 103 case histories, I attempted to tease out whether or not specific types of habitat development were consistently more beneficial to either trout species. These attempts failed to provide any consistent patterns. However, when in sympatry with brook trout, habitat development appears to favor brown trout (Table 10).

Unfortunately, case history evaluations weak in experimental design dominate the present compendium and they were given the same importance as those reports based on more comprehensive evaluations in determining relative success rates. This should be kept in mind when readers reflect upon the reported composite results. Nonetheless, this study provides the most comprehensive evaluation of habitat development techniques to improve standing stocks of trout in Wisconsin and the upper Midwest.

Funds collected from the annual sale of Wisconsin trout stamps will continue to provide moneys to be spent for trout stream habitat development projects. Future evaluations of the success or failure of these development projects should continue to be a high priority for the Wisconsin DNR. However, I must point out two weaknesses in experimental design if they are to be rectified. One weakness is the lack of a "reference zone" in conjunction with a "treatment zone" in each habitat evaluation project. Just using a before and after comparison in a "treatment zone" fails to eliminate the natural variation in the trout population from the perceived response to habitat development. Instead, using a "reference zone" would eliminate this variable and reveal the true quantitative response to habitat manipulation.

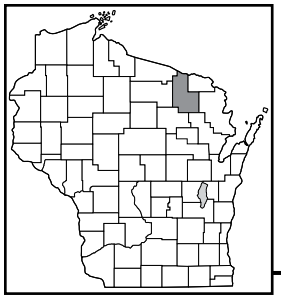
The second weakness is a lack of reliable creel census information on angler use and harvest before and after habitat development. Numerous fishery managers commented in their source documents that increased use and harvest were suspected in "treatment zones" after development, but no data is available to validate these suppositions. Increased harvest and not depression of trout carrying capacity could have caused documented post-development reductions or modest increases in standing stocks in some "treatment zones".

Finally, the growing interest in the impact of human activities on non-game species and endangered plants and animals makes it imperative for the Wisconsin DNR to evaluate the impacts of habitat development upon other vertebrates, invertebrates, and plants within the aquatic community and riparian corridor. Such multidisciplinary studies are beyond the expertise of fisheries managers and will necessitate both physical and monetary cooperation and involvement from many other disciplines within and outside the Wisconsin DNR. With increasing budget constraints, this charge is not meant to spawn ''sighs" of hopelessness but rather to encourage better long-term planning and to ensure that future studies have an experimental design that will quantitatively answer as many questions as possible.

Case Histories:

Stream	Principal Investigator(s)	Page
Allen Creek 1	D. Brum	21
Allen Creek 2	D. Brum	22
Allenton Creek	T. Ehlinger, B. Berner, and T. Slawski	23
Big (Cataract) Creek	E. Avery	24
Brown Spur Creek[a]	E. Avery	61
Camp Creek	R. Hunt	25
Chaffee Creek	E. Avery	26
Clam River	R. Cornelius	27
Cooks & Bullets Creek[a]	E. Avery	61
Davis/Clayton Creek	R. Hunt	28
Devils Creek	R. Hunt	29
East Branch Eau Claire	D. Seiber, A. Hauber, and P. Segerson	31
East Cataline Creek[a]	E. Avery	61
Elvoy Creek 1	S. AveLallemant and D. Brum	33
Elvoy Creek 2	S. AveLallemant and D. Brum	34
Elvoy Creek 3	L. Andrews, S. AveLallemant, and D. Brum	35
Emmons Creek	E. Avery	37
Ernst Creek[a]	E. Avery	61
Evergreen River	M. Johnson	38
First South Branch Oconto River	R. Heizer and C. Sebero	39
Fordham Creek	S. Ironside, D. Kufalk, and D. Paynter	40
Genrick Creek[a]	E. Avery	61
Hay Creek (Chippewa Co.)	E. Avery	41
Hay Creek (Oconto Co.)	R. Heizer and T. Thuemler	43
Hunting River 1	A. Hauber	44
Hunting River 2	A. Hauber	45
K.C. Creek	R. Heizer and C. Sebero	46
LaMontagne Creek	R. Heizer and C. Sebero	47
Lepage Creek	R. Heizer and C. Sebero	48
Little Evergreen River	D. Seibel and M. Johnson	49
Little Roche a Cri Creek	S. Ironside and D. Paynter	50
Lodi (Spring) Creek	T. Larson	51
Lost Creek[a]	E. Avery	61
Manley Creek	T. Larson	52
McKenzie Creek	R. Cornelius	53
Mecan River	M. Primising	54
Middle Branch Embarrass River	R. Langhurst	55
Middle Inlet Creek (upper)	R. Heizer and C. Sebero	56
Millville Creek	E. Avery	57
Murray Creek	A. Neiber, E. Avery, and C. Cason	58
Neenah Creek	S. Ironside and D. Paynter	59
No Name Creek[a]	E. Avery	61
North Branch Beaver Creek	R. Heizer and C. Sebero	60
North Branch Pemebonwon River	E. Avery, R. Heizer, and K. Niermeyer	61
North Branch Prairie River	D. Seibel, P. Segerson, and M. Johnson	63
North Otter Creek	S. AveLallemant, D. Brum, and L. Andrews	64
Paradise Spring Creek	S. Beyler	65
Prairie River (below R & H Road)	A. Hauber and D. Seibel	66
Prairie River (section 35)	A. Hauber and D. Seibel	68
Price Creek	J. Lealos	70
Rowan Creek	T. Larson	71
Spring Brook	T. Sommerfeldt and J. Roth	72
Tomorrow River (upper)	S. Ironside and D. Paynter	73
Twenty Mile Creek	R. Hunt	74
Waupaca River	A. Niebur and E. Avery	76
Waupee Creek	E. Avery, R. Heizer, and K. Niermeyer	77
Whitcomb Creek	A. Niebur and C. Cason	79
Wisconsin Creek	R. Heizer and C. Sebero	80

[a] See North Branch Pemebonwon River



ALLEN CREEK 1

Forest County
Wild Brook Trout
Category 2 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 8.9 miles including 8.9 miles of trout water
Average Width: 14.8 ft
pH: 7.5
Total Alkalinity: 97 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
The creek channel was excavated and single and double whole logs and boulders were added to the creek.

STUDY PERIOD AND DESIGN
There was a 0.26 mile treatment zone with no reference zone. Abundance and biomass of trout were surveyed August 1995. Habitat development occurred in June 1996. Post-development trout population surveys were made in August 1998 and July 1999.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was David Brum.

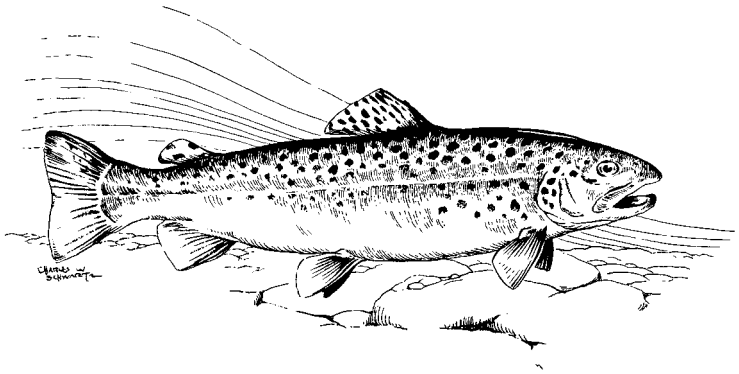
SUMMARY OF FINDINGS
The post-development abundance of wild brook trout declined 24% while biomass increased 79% (Table 17). A 50% decline in natural recruitment (abundance) of age 0 fish (trout <4 inches) explained most of the population decline while an increase in larger brook trout accounted for the increase in biomass.

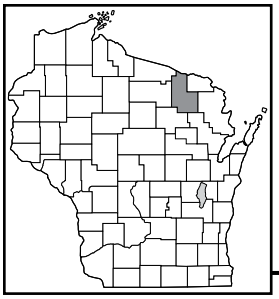
The average abundance of legal-size brook trout (≥7 inches) increased 133% after habitat development and post-development abundance of brook trout ≥9 inches increased 82% (Table 17).

SOURCE DOCUMENT
D. Brum, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 10 Jan 2000.

Table 17. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout in the Allen Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	2,037	1,542	-24
Number of trout per mile <4 inches	1,609	806	-50
Number of trout per mile ≥7 inches	157	366	133
Number of trout per mile ≥9 inches	73	133	82
Pounds of trout per mile	73.5	131.2	79





ALLEN CREEK 2

Forest County
Wild Brook Trout
Category 2 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 8.9 miles including 8.9 miles of trout water
Average Width: 14.8 ft
pH: 7.5
Total Alkalinity: 97 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
The creek channel was excavated and single and double whole logs, and boulders were added to the creek.

STUDY PERIOD AND DESIGN
There was a 0.26 mile treatment zone with no reference zone. Pre-development trout population surveys were made in August 1994 and July 1995. Habitat development occurred in August 1996. Post-development trout population surveys were made in August 1998 and July 1999. Average pre- and post-development trout population characteristics were compared.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was David Brum.

SUMMARY OF FINDINGS
The post-development abundance of brook trout declined 67% while biomass increased 131% (Table 18). An 87% decline in the abundance of age 0 trout (trout <4 inches) explains the decline in total abundance of brook trout, while an increase in larger size trout accounted for the increase in biomass. The average abundance of legal-size brook trout (≥7 inches) increased 487% after habitat development. Brook trout ≥9 inches were absent prior to habitat development. Following development, an average abundance of 71 trout per mile was found representing a 7,100% increase.

Wild brown trout occasionally move out of the Brule River upstream and travel into Allen Creek but do not reproduce in the creek. The post-development abundance and biomass of wild brown trout increased 200% and 550%, respectively, but comprised less than 3% of the total trout community.

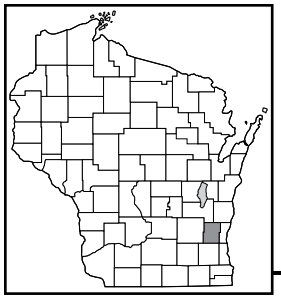
The post-development abundance of all trout declined 66% while biomass increased 136% (Table 18). Legal-size trout (≥7 inches) increased 524% and consisted primarily of brook trout. The increased biomass of legal-size trout offset the 87% decline in abundance of age 0 brook trout and the related loss in biomass.

SOURCE DOCUMENT
D. Brum, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 10 Jan 2000.

Table 18. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and wild brown trout in the Allen Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Average	Post-dev. Average	Percent Change
Total number of trout per mile	Brook	1,822	595	-67
	Brown[a]	6	18	200
	Combined	1,828	613	-66
Number of trout per mile <4 inches	Brook	1,583	209	-87
	Brown	0	0	0
Number of trout per mile ≥7 inches	Brook	38	223	487
	Brown	0	14	1,400
	Combined	38	237	524
Number of trout per mile ≥9 inches	Brook	0	71	7,100
	Brown	0	0	0
Pounds of trout per mile	Brook	31.7	73.2	131
	Brown	0.4	2.6	550
	Combined	32.1	75.8	136

[a]Brown trout do not reproduce in the stream but move up into Allen Creek from the Brule River.



ALLENTON CREEK

Washington County
Wild Brook Trout
Category 3 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 3.5 miles including 3.5 miles of trout water
Average Width: 6.7 ft
pH: 7.8
Total Alkalinity: 304 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There was new stream channel construction and relocation due to the widening of U.S. Highway 41. As a result, wing deflectors, channel constrictors, lateral logs, cross-log revetments, brush bundles, root wads, channel blocks, boulders, half-logs, and rip-rap were added to the creek.

STUDY PERIOD AND DESIGN
There was a 0.04 mile treatment zone before the new stream channel construction and relocation and a 0.26 mile treatment zone that consisted of the entire newly constructed stream channel following construction. There was a 0.04 mile stream segment above and below the treatment zone creating a 0.08 mile reference zone prior to stream channel construction, and a 0.11 mile stream segment above and below the treatment zone creating a 0.22 mile reference zone after stream channel construction. A pre-development trout population survey was conducted in all study zones July 1993. The new stream channel was constructed adjacent to the old channel in winter 1993-94 and included 78 in-stream habitat structures (Table 19). The newly constructed stream was diverted into the new channel beginning in spring 1994 and a post-development trout population survey was conducted July 1997.

PROJECT COST
The estimated cost for this project was $600,000.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Tim Ehlinger, Brian Berner, and Tom Slawski.

SUMMARY OF FINDINGS
The post-development abundance of wild brook trout increased 116% in the newly constructed stream channel. A 50% post-development abundance increase occurred in the reference zone and there was a 66% net gain in abundance following habitat development (Table 20).

Brook trout ≥6 inches increased 159% in the treatment zone and 22% in the reference zone. The net gain in total abundance of brook trout ≥6 inches following habitat development was 137%.

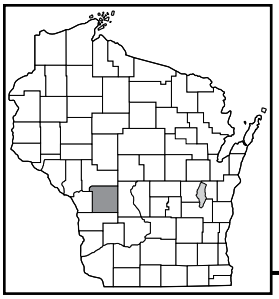
SOURCE DOCUMENT
B. Berner, University of Wisconsin-Milwaukee, to E. Avery, interagency memo. 14 Jun 2001.

Table 19. *Summary of habitat structures installed in Allenton Creek, Washington County, Wisconsin 1993-94.*

Type of habitat structure	Number installed
Boulders	21
Boulder berms	5
Boulder retards	1
Brush bundles	9
Brush (additions)	2
Channel constrictors	4
Channel blocks	2
Cobble-boulders	2
Crib banks	1
Cross-log revetments	4
Half-logs	1
Lateral logs	11
Riprap	6
Root wads	4
Stumps	1
Wing deflectors	4
Total	78

Table 20. *Abundance (number of trout per mile) of wild brook trout in the Allenton Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Population Characteristic	Study Zone	Pre-dev. Value	Post-dev. Value	Percent Change
Total number of trout per mile	TZ	189	409	116
	RZ	135	202	50
Number of trout per mile ≥6 inches	TZ	81	210	159
	RZ	81	99	22
Number of trout per mile ≥7 inches	TZ	81	199	147
	RZ	81	99	22



BIG (CATARACT) CREEK

Monroe County
Wild and Domestic Brook Trout
Category 2 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 6.3 miles including 6.3 miles of trout water
Average Width: 26.5 ft
pH: 7.3
Total Alkalinity: 32 ppm
Gradient: 12 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
A sediment trap and gravel spawning riffle were added to the creek.

STUDY PERIOD AND DESIGN
A sediment trap and a rock-sill-gravel spawning riffle were installed in Big Creek during the summer 1989. A 0.38 mile treatment zone began at the upper end of the gravel spawning riffle and extended downstream. A 0.23 mile reference zone extended upstream and included the sediment trap. Post-development trout population surveys were made in both zones during August 1990-91.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Ed Avery.

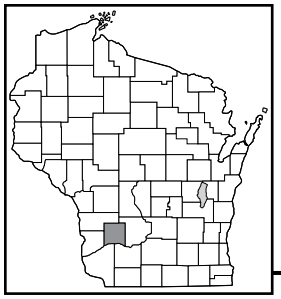
SUMMARY OF FINDINGS
There were no positive changes in the natural recruitment of brook trout or in the total population of brook trout in the treatment zone that could be attributed to habitat development. Approximately 99% of brook trout <6 inches were wild young-of-year or age 0 fish. Brook trout ≥6 inches were age I+ fish. Post-development abundance of brook trout <6 inches increased 89% between 1990 and 1991 (Table 21). However, a 119% increase of brook trout <6 inches occurred in the reference zone during the same period.

Brook trout ≥6 inches declined 30% in the treatment zone and 42% in the reference zone between 1990 and 1991. The total abundance of brook trout increased 40% in the treatment zone and 74% in the reference zone during the two years following habitat development (Table 21).

SOURCE DOCUMENT
E. Avery, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files.

Table 21. *Abundance (number of trout per mile) of wild and domestic brook trout in the Big creek treatment zone (TZ) and reference zone (RZ) in August 1990-91; the first and second years after habitat development.*

Population Characteristic	Study Zone	1990	1991	Percent Change
Number of trout per mile <6 inches	TZ	726	1,371	89
	RZ	430	943	119
Number of trout per mile ≥6 inches	TZ	497	347	-30
	RZ	165	96	-42
Number of trout per mile ≥10 inches	TZ	61	18	-70
	RZ	21	3	-86
Total number of trout per mile	TZ	1,224	1,718	40
	RZ	596	1,039	74



CAMP CREEK

Richland County
Wild Brown Trout
1986 Southern Wisconsin Trout Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 5.5 miles including 5.5 miles of trout water
Average Width: 8.5 ft
pH: 8.0
Total Alkalinity: 247 ppm
Base Flow Stream Discharge: 2.6 cfs
Gradient: 71 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were bank cover logs, wing deflectors, channel constrictors, K dams, tip deflectors, wedge dams, and whole log covers added to the creek.

STUDY PERIOD AND DESIGN
There was a two-part 0.24 mile treatment zone; the 0.11 mile reference zone sandwiched between upper and lower segments of the treatment zone. The habitat structures were installed from August to September 1985 and trout populations in the study zones were surveyed in April 1984-89. Physical characteristics of the study zones, including average width, average depth, underbank hiding cover, and stream discharge were measured in April 1984 and September 1988. Underbank hiding cover was defined as the face length of stream bank providing at least 0.5 ft of overhang with at least 0.5 ft of water beneath it.

This study was part of a larger investigation of habitat improvement structures on high gradient streams involving Devils Creek (1983-89) and Twenty Mile Creek (1983-89).

PROJECT COST
The estimated cost for this project was $37,987 per mile of habitat improvement. The cost includes supplies, wages, vehicle mileage, and heavy equipment rental.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Robert Hunt.

SUMMARY OF FINDINGS
The most dramatic physical change in the treatment zone following habitat development was a 1,313% increase in under bank hiding cover for trout (Table 22). This occurred even though baseflow stream discharge measured in 1988 was 54% less than measured in 1984. Other positive responses to habitat development in the treatment zone included a 27% decline in average width and a 21% increase in average depth. In the reference zone, under bank hiding cover declined 52% in response to the reduction in base flow stream discharge. The average width and average depth in the reference zone increased 7% and declined 11%, respectively.

Positive changes occurred among all characteristics of the wild brown trout population in the treatment zone after habitat development. The average abundance of age I+ brown trout in April increased 271% in the treatment zone compared to an increase of 256% in the reference zone (Table 23). In the treatment zone, the abundance of brown trout ≥9 inches increased 59% and brown trout ≥12 inches increased 88% with the total biomass increasing 117%. The abundance and biomass of the larger brown trout (≥9 inches) all declined in the reference zone.

SOURCE DOCUMENT
Hunt, R.L. 1992. Evaluation of trout habitat improvement structures in three high-gradient streams in Wisconsin. Wisconsin Department of Natural Resources. *Technical Bulletin* 179:1-40

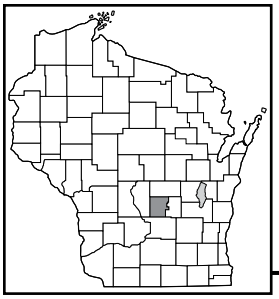
Table 22. *Physical characteristics of the Camp Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Characteristic	Study Zone	Pre-dev. Value	Post-dev. Value	Percent Change
Average width (feet)	TZ	9.4	6.9	-27
	RZ	8.2	8.7	7
Average depth (inches)	TZ	4.8	5.8	21
	RZ	5.7	5.1	-11
Bank cover (linear feet)	TZ	23.3	329.3	1,313
	RZ	63.3	30.7	-52
Stream baseflow (cubic feet per second)	TZ	2.6[a]	1.2	-54

[a]Baseflow discharge measured in September 1984.

Table 23. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild, age I+ brown trout in the Camp Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Population Characteristic	Study Zone	Pre-dev. Value	Post-dev. Average	Percent Change
Number of trout per mile age I+	TZ	490	1,819	271
	RZ	464	1,653	256
Number of trout per mile ≥9 inches	TZ	208	330	59
	RZ	382	138	-64
Number of trout per mile ≥12 inches	TZ	16	30	88
	RZ	73	20	-73
Pounds of trout per mile	TZ	123	267	117
	RZ	216	173	-20



CHAFFEE CREEK

Marquette County
Wild and Domestic Brown Trout
Category 3 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
Age I brown trout were stocked annually in the spring 0.4 miles below the treatment zone.

STREAM DESCRIPTION
Total Length: 12.3 miles including 10.5 miles of trout water
Average Width: 15.7 ft
pH: 8.0
Total Alkalinity: 156 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There was a sediment trap and gravel spawning riffle added to the creek.

STUDY PERIOD AND DESIGN
There was a 1.0 mile treatment zone with a 0.25 mile reference zone upstream of the treatment zone. A sediment trap, with an average width of 17.4 ft and an average depth of 3.3 ft, was excavated in the upper 220 ft of the treatment zone in February 1986. The sediment trap was cleaned annually from 1986-90. A 75 ft rock-sill-gravel riffle, encompassing 775 sq. ft of potential spawning area, was constructed 0.1 miles downstream of the sediment trap in October 1987. Physical characteristics of both study zones were measured in September 1985 and June 1989 (Table 25). Trout population surveys were conducted in August 1984-91 in both study zones.

This study was part of a larger investigation of sediment traps and artificial gravel riffles to improve trout reproduction involving Hay Creek (1984-90) and Waupee Creek (1986-91).

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Ed Avery.

SUMMARY OF FINDINGS
The primary objective of habitat development was to increase gravel substrates and improve natural reproduction of trout. Unfortunately, the post-development response of the wild brown trout population was disappointing. The total abundance of brown trout in the treatment zone increased 13% but also increased 12% in the reference zone (Table 24).

The post-development abundance of age 0 brown trout in the treatment zone increased 145% but also increased 400% in the reference zone (Table 24). From a numerical standpoint, it appears that habitat development failed to substantially improve natural recruitment of brown trout.

The post-development changes in the physical characteristics of the stream were mostly positive. The average stream depth increased 20% in the treatment zone but declined 13% in the reference zone (Table 25). The increase in water depth was anticipated in the treatment zone as a result of increased vertical scouring downstream of the excavated sediment trap. The average stream width in the treatment zone and reference zone increased 11% and 2%, respectively and may have been caused by lateral scouring and sloughing of the stream bank. Incidence of gravel substrates (transects with gravel and sites within transects with gravel) increased slightly in the treatment zone but was primarily in response to the addition of the gravel riffle (habitat development).

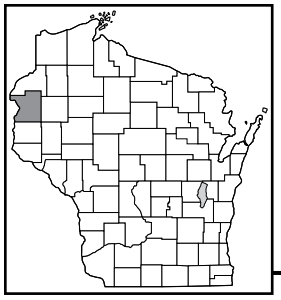
SOURCE DOCUMENT
Avery, E. L. 1996. Evaluations of sediment traps and artificial gravel riffles constructed to improve reproduction of trout in three Wisconsin streams. *North American Journal of Fisheries Management* 16:282-293.

Table 24. *Abundance (number of trout per mile) of wild and stocked brown trout in the Chaffee Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Population Characteristic	Study Zone	Pre-dev. Average	Post-dev. Average	Percent Change
Total number of trout per mile	TZ	829	940	13
	RZ	465	521	12
Number of wild age 0 trout per mile	TZ	11	27	145
	RZ	0	4	400
Number of age I+ trout per mile	TZ	818	913	12
	RZ	465	517	11

Table 25. *Characteristics of the Chaffee Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

	RZ			TZ		
Physical Characteristic	Pre-dev. Value	Post-dev. Value	Percent Change	Pre-dev. Value	Post-dev. Value	Percent Change
Stream discharge (cubic feet per second)				23.3	23.3	0
Average width (feet)	15.4	15.7	2	14.8	16.4	11
Average depth (feet)	1.6	1.4	-13	1.5	1.8	20
Percentage of transects with gravel	38	38	0	62	67	5
Percentage of sites within transects with gravel	6	5	1	12	15	3



CLAM RIVER

Polk County
Wild Brook Trout and Wild Brown Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 22.8 miles including 17.5 miles of trout water
Average Width: 20 ft
Total Alkalinity: 22 ppm
Gradient: 15 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
In 1978, stream bank was debrushed and half-logs were added to the river. In 1983 riprap, current (wing) deflectors, brush mats, channel blocks, and bank cover were added to the river.

STUDY PERIOD AND DESIGN
There was one 0.47 mile treatment zone with no reference zone. A pre-development trout population survey was made in the treatment zone in July 1978. Habitat development occurred during late summer 1978 and annual trout population surveys were conducted in July-August 1979-82. Additional habitat development occurred in the treatment zone in 1983 and trout population surveys were conducted in July 1984-85, 1987, and 1994. The 1978 pre-development trout population survey is compared to the average of the 1979-82 post-development population surveys, as well as, the average of the 1984-85, 1987 and 1994 post-development surveys.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Rick Cornelius.

SUMMARY OF FINDINGS
The wild brook trout population was more numerous than the wild brown trout population before and after habitat development. However, wild brown trout responded proportionately better to habitat development than wild brook trout and increased their percentage of the total trout population (Table 26).

The average post-development abundance of wild brook trout declined 17% after the first 4 year period and 20% by the end of the second 4 year period (Table 26). Average post-development abundance of wild brown trout increased 277% during the first 4 year period and 769% by the end of the second 4 year period.

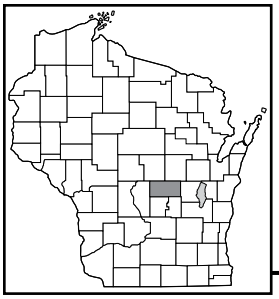
The average abundance for both species of larger trout (≥8 inches) increased following habitat development with greater proportional gains seen by wild brown trout. Post-development abundance of wild brook trout ≥8 inches increased 71% during the first 4 year period and 124% by the end of the second 4 year period (Table 26). Post-development abundance of wild brown trout ≥8 inches increased 550% during the first 4 year period. By 1994, the average post-development abundance increased to 1,525%.

The post-development abundance of all trout (≥5 inches) declined 10%, however, abundance of larger trout (≥8 inches) increased 230%.

SOURCE DOCUMENT
R. Cornelius, Wisconsin Department of Natural Resources, to B. Smith, intradepartmental memo. 13 Sept 1994.

Table 26. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and brown trout in the Clam River treatment zone (TZ) before (pre) and after (post) habitat development in 1978 and habitat development in 1983.*

Trout Species	Population Characteristic	1978 Pre-dev. Value	1979-82 Post-dev. Average	Percent Change	1984-85 and 1987-94 Post-dev. Average	Percent Change
Brook	Number of trout per mile ≥5 inches	1,048	870	-17	837	-20
Brook	Number of trout per mile ≥8 inches	49	84	71	110	124
Brown	Number of trout per mile ≥5 inches	13	49	277	113	769
Brown	Number of trout per mile ≥8 inches	4	26	550	65	1,525
Combined	Number of trout per mile ≥5 inches	1,061	919	-13	950	-10
Combined	Number of trout per mile ≥8 inches	53	110	108	175	230



DAVIS/CLAYTON CREEK

Waushara County
Wild Brook Trout and Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 2.2 miles including 2.2 miles of trout water
pH: 8.2
Total Alkalinity: 175 ppm
Gradient: 2 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were bank (boom) covers, wing deflector, boulder retards, and riprap added to the creek. In addition, the bank was debrushed and debris removed from the channel.

STUDY PERIOD AND DESIGN
This habitat development project was a joint effort between the Wisconsin DNR and Fox Valley Chapter of Trout Unlimited (TU). There was a 0.1 mile treatment zone with a 0.1 mile reference zone. Trout population surveys were made in April 1982 and 1987. Volunteer TU workers supervised by a Wisconsin DNR land agent (Elward Engle) did habitat development work during the summer 1983-84.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principle investigators for this project were Elward Engle and Robert Hunt.

SUMMARY OF FINDINGS
The habitat development benefited yearling and older trout. Development also triggered a response in species composition, favoring brown trout over brook trout.

In the treatment zone post-development abundance of trout declined 13% but abundance of legal-size trout (≥6 inches) increased 590% (Table 27). In the reference zone, the total abundance of trout declined 2% but the abundance of legal-size trout increased 153%.

The post-development abundance of brook trout declined 90% in the treatment zone and increased 38% in the reference zone (Table 27). The legal-size brook trout (≥6 inches) disappeared from the treatment zone but increased 153% in the reference zone. In the treatment zone, the total abundance of brown trout increased 25% after development but decreased 25% in the reference zone. The legal-size brown trout increased 762% in the treatment zone but increased only 153% in the reference zone.

The total biomass of trout increased 113% in the treatment zone and increased 29% in the reference zone. Biomass of brook trout declined 88% in the treatment zone but increased 69% in the reference zone. The brown trout biomass increased 214% in the treatment zone and remained status quo in the reference zone.

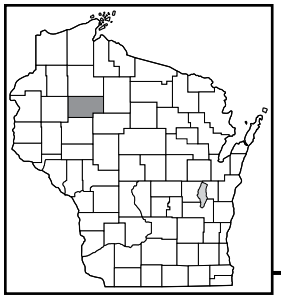
SOURCE DOCUMENTS
R.L. Hunt, Wisconsin Department of Natural Resources, to M. Primising, intradepartmental memo. 9 Apr 1987.

R.L. Hunt, Wisconsin Department of Natural Resources, to Cold Water Research Files, intradepartmental memo. No Date.

R.L. Hunt, Wisconsin Department of Natural Resources, to E. Avery, phone conversation. 12 Jan 2000.

Table 27. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and wild brown trout in the Davis/Clayton Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Study Zone	Pre-development Value	Post-development Value	Percent Change
Brook	Total number of trout per mile	TZ	676	69	-90
		RZ	384	529	38
	Number of trout per mile ≥6 inches	TZ	21	0	-100
		RZ	19	48	153
	Pounds of trout per mile	TZ	26	3	-88
		RZ	13	22	69
Brown	Total number of trout per mile	TZ	1,362	1,701	25
		RZ	653	490	-25
	Number of trout per mile ≥6 inches	TZ	84	724	762
		RZ	19	48	153
	Pounds of trout per mile	TZ	52	163	214
		RZ	18	18	0
Combined	Total number of trout per mile	TZ	2,038	1,770	-13
		RZ	1,037	1,019	-2
	Number of trout per mile ≥6 inches	TZ	105	724	590
		RZ	38	96	153
	Pounds of trout per mile	TZ	78	166	113
		RZ	31	40	29



DEVILS CREEK

Rusk County
Wild and Domestic Brook Trout and Domestic Brown Trout
Pre-1990 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
Age I brook trout and age I brown trout were stocked annually in the spring.

STREAM DESCRIPTION
Total Length: 18.0 miles including 18.0 miles of trout water
Average Width: 20 ft
pH: 7.2
Total Alkalinity: 55 ppm
Base Flow Stream Discharge: 12.1 cfs
Gradient: 53 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were bank cover logs, wing deflectors, channel constrictors, and whole log covers added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.10 mile treatment zone with one 0.15 mile reference zone. The habitat structures were installed during September and October 1985. Trout populations in the study zones were surveyed during September 1983-89. Physical characteristics of the study zones (average width, average depth, under bank hiding cover, stream discharge, etc.) were measured in September 1983 and August 1989. Under bank hiding cover was defined as the face length of stream bank providing at least 0.5 ft of overhang with at least 0.5 ft of water beneath it.

This study was part of a larger investigation of habitat improvement structures on high gradient streams involving Camp Creek (1984-89) and Twenty Mile Creek (1983-89).

PROJECT COST
The cost of the project was approximately $54,633 per mile including supplies, wages, vehicle mileage, and heavy equipment rental.

PRINCIPAL INVESTIGATOR(S)
The principal investigator on the project was Robert Hunt.

SUMMARY OF FINDINGS
The most dramatic physical change in the treatment zone following habitat development was a 1,130% increase in under bank hiding cover for trout (Table 28). This occurred even though base stream flow discharge measured in 1989 was 57% less than that measured in 1983. Under bank hiding cover in the reference zone declined 8% in response to the reduction in base stream flow discharge. The other positive response to habitat development in the treatment zone was an average 35% increase in water depth at the specific structure sites (Table 29).

The three population characteristics of the standing stocks of brook trout showed post-development increases over pre-development values, but in all cases the percentage increased was greater in the reference zone than in the treatment zone (Table 30). For brown trout the opposite pattern emerged which suggests benefits of habitat improvement structures. Abundance of brown trout increased an average of 90% in the treatment zone and declined an average of 81% in the reference zone. Legal-size brown trout (≥6 inches) in September increased 150% in the treatment zone and declined 64% in the reference zone while biomass improved 47% in the treatment zone and declined 49% in the reference zone.

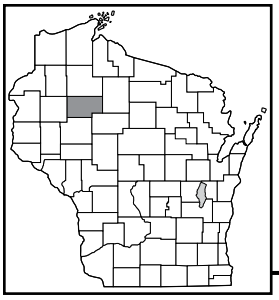
The post-development abundance of all trout combined increased in both study zones; total abundance increased 52% in the treatment zone and 16% in the reference zone, while legal-size trout (≥6 inches)increased 151% in the treatment zone and 74% in the reference zone (Table 30). Biomass increased 53% in the treatment zone but only 16% in the reference zone.

SOURCE DOCUMENT
Hunt, R.L. 1992. Evaluation of trout habitat improvement structures in three high-gradient streams in Wisconsin. Wisconsin Department of Natural Resources. *Technical Bulletin* 179:1-40

Table 28. *Physical characteristics of the Devils Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Characteristic	Study Zone	Pre-dev. Value	Post-dev. Value	Percent Change
Average width (feet)	TZ	23.5	14.7	-37
	RZ	28.3	21.6	-24
Average depth (inches)	TZ	7.2	4.4	-39
	RZ	7.8	5.7	-27
Bank cover (linear feet)	TZ	11.5	141.4	1,130
	RZ	37	34	-8
Stream baseflow (cubic feet per second)	TZ	12.1	5.2	-57

continued on page 30



DEVILS CREEK (continued)

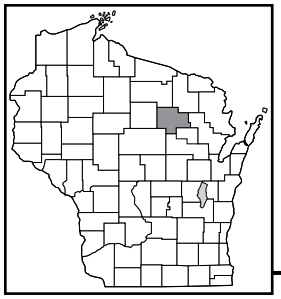
Rusk County
Wild and Domestic Brook Trout and Domestic Brown Trout
Pre-1990 Trout Fishing Regulations
Class II Trout Stream

Table 29. *Average water depths at 4 stream channel sites (non-random) on the Devils Creek treatment zone before and after habitat development at those sites.*

Site	Habitat Development	Average Water Depth (inches) Before	After	Percent Change
1	Wing deflector/ bank cover log	4.7	7.0	49
2	Wing deflector/ bank cover log	4.7	8.1	72
3	Wing deflector/ bank cover log	5.0	5.6	12
4	Channel constrictor	6.1	6.9	13
	Average	5.1	6.9	35

Table 30. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of age 0 and older brook trout and brown trout in the Devils Creek treatment zone (TZ) and reference (RZ) zone before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Study Zone	Pre-development Avg.	Post-development Avg.	Percent Change
Brook	Total number of trout per mile	TZ	217	322	48
		RZ	142	252	77
	Number of trout per mile ≥6 inches	TZ	43	108	151
		RZ	33	107	224
	Pounds of trout per mile	TZ	12.9	20.1	56
		RZ	7.8	21.2	172
Brown	Total no./mile	TZ	20	38	90
		RZ	89	17	-81
	Number of trout per mile ≥6 inches	TZ	10	25	150
		RZ	36	13	-64
	Pounds of trout per mile	TZ	5.1	7.5	47
		RZ	18.9	9.7	-49
Combined	Total number of trout per mile	TZ	237	360	52
		RZ	231	268	16
	Number of trout per mile ≥6 inches	TZ	53	133	151
		RZ	69	120	74
	Pounds of trout per mile	TZ	18	27.6	53
		RZ	26.7	30.9	16



EAST BRANCH EAU CLAIRE RIVER

Langlade County
Wild and Domestic Brook Trout, Wild and Domestic Brown Trout, and Domestic Rainbow Trout
Category 5 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 28.3 miles including 17.0 miles of trout water
Average Width: 22 ft
pH: 6.3
Total Alkalinity: 52 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were skyhook boom covers, wing deflectors, and boulders added to the river.

STUDY PERIOD AND DESIGN
There was one 0.44 mile treatment zone with one adjacent downstream 0.33 mile reference zone. One pre-development survey of trout in both study zones was made in June 1983. Habitat development followed in July and August 1983. The post-development inventories of standing stocks in both study zones were made in June 1986 and 1989. This was before statewide changes in angling regulations were implemented in 1990. In 1990, an artificial lure only gear restriction was implemented along with a daily bag limit of 2 trout (1 of which may be a brown or rainbow trout and 1 of which may be a brook trout). A minimum size restriction of 20 inches for brown and rainbow trout and 14 inches for brook trout was also implemented.

Due to the new angling restrictions, additional post-development inventories of standing stocks in both study zones were made in June and July 1992, 1995, and 1997-99. In this report, the pre-development trout population is compared with the average post-development standing stocks for 1986 and 1989, and the combined average standing stock for the 1990's (1992, 1995, and 1997-99). All population estimates included age I+ trout over 4 inches. Biomass data was included for standing stocks surveyed in the 1980's but not for standing stocks surveyed in the 1990's.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were David Seibel, Al Hauber, and Peter Segerson.

SUMMARY OF FINDINGS
Stocked trout (identified by finclips) comprised very small segments of brook and brown trout standing stocks. As a result, both species of stocked (domestic) and wild trout were combined for standing stock comparisons. Comparisons are potentially complicated because stocking protocols (number and date stocked) were not provided in the source document.

In 1986 and 1989, post-development abundance of brook trout declined 32% in the reference zone and 31% in the treatment zone and abundance of brook trout larger than 8 inches increased 146% in the treatment zone but declined 57% in the reference zone (Table 31). Total biomass of brook trout increased 13% in the treatment zone and declined 40% in the reference zone.

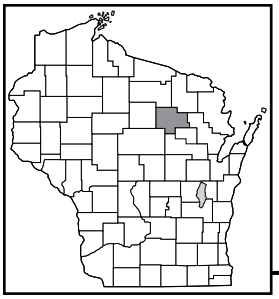
The brown and rainbow trout were minor components of the trout community before and after habitat development. The post-development abundance of both species in 1986 and 1989 improved in the treatment zone but did not change or declined in the reference zone. The abundance of brown trout increased 1050% in the treatment zone but declined 17% in the reference zone (Table 31). The rainbow trout abundance increased 280% in the treatment zone and were never present in the reference zone (Table 31).

By the late 1990's, the average post-development abundance of brook trout declined 25% in the reference zone and increased 68% in the treatment zone (Table 31). The greatest brook trout population increases in the treatment zone occurred with the larger size trout. Brook trout larger than 8 inches increased 514%, brook trout larger than 10 inches increased 750% (Table 31). In the reference zone, brook trout larger than 8 inches declined 55% and brook trout larger than 10 inches declined 89%.

The post-development abundance of brown trout in the 1990's declined 100% in the reference zone but increased 1050% in the treatment zone (Table 31). Similar to brook trout, the greatest increases were in the larger size groups. This river is one example where habitat improvement did not improve brown trout populations at the expense of the brook trout population. Natural recruitment of brown trout and rainbow trout was minimal and was responsible for their low population.

SOURCE DOCUMENT
D. Seibel, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. Apr 2000.

continued on page 32

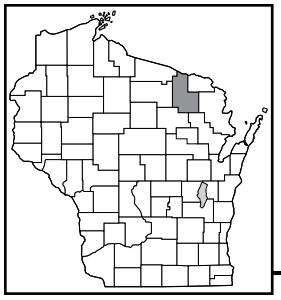


EAST BRANCH EAU CLAIRE RIVER (continued)

Langlade County
Wild and Domestic Brook Trout, Wild and Domestic Brown Trout, and Domestic Rainbow Trout
Category 5 Trout Fishing Regulations
Class II Trout Stream

Table 31. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild and domestic brook trout, wild and domestic brown trout, and domestic rainbow trout in the East Branch Eau Claire River treatment zone (TZ) and reference (RZ) before (pre) and after (post) habitat development. N/A = data not available*

Trout Species	Population Characteristic	Study Zone	1983 Pre-dev. Value	1986 and 1989 Post-dev. Average	Percent Change	1997-1999 Post-dev. Average	Percent Change
Brook	Total number of trout per mile	RZ	4,526	3,079	-32	3,399	-25
		TZ	1,866	1,295	-31	3,134	68
	Number of trout per mile ≥6 inches	RZ	2,996	1,656	-45	1,333	-56
		TZ	1,341	1,212	-10	1,983	48
	Number of trout per mile ≥8 inches	RZ	414	177	-57	188	-55
		TZ	144	354	146	884	514
	Number of trout per mile ≥10 inches	RZ	66	2	-97	7	-89
		TZ	30	142	373	255	750
	Pounds of trout per mile	RZ	508	305	-40	N/A	N/A
		TZ	214	241	13	N/A	N/A
Brown	Total number of trout per mile	RZ	6	5	-17	0	-100
		TZ	2	23	1,050	49	2,350
	Number of trout per mile ≥6 inches	RZ	6	5	-17	0	-100
		TZ	2	23	1,050	49	2,350
	Number of trout per mile ≥8 inches	RZ	6	5	-17	0	-100
		TZ	0	22	2,200	43	4,300
	Number of trout per mile ≥10 inches	RZ	6	0	-100	0	-100
		TZ	0	16	1,600	15	1,500
	Pounds of trout per mile	RZ	8	2	-75	N/A	N/A
		TZ	<1	32	3,200	N/A	N/A
Rainbow	Total number of trout per mile	RZ	0	0	0	0	0
		TZ	5	19	280	0	0
	Number of trout per mile ≥6 inches	RZ	0	0	0	0	0
		TZ	5	19	280	0	0
	Pounds of trout per mile	RZ	0	0	-55	0	0
		TZ	1	5	247	0	0



ELVOY CREEK 1

Forest County
Wild Brook Trout and Wild Brown Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 9.6 miles including 9.6 miles of trout water
Average Width: 36.1 ft
pH: 6.6
Total Alkalinity: 51 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
The creek channel was excavated and single and double whole logs and boulders were added.

STUDY PERIOD AND DESIGN
There was a 0.42 mile treatment zone with no reference zone. The pre-development trout population surveys were made in July 1997. The post-development trout population surveys were made in July 1999. The habitat development occurred in July 1998.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Steve AveLallemant and David Brum.

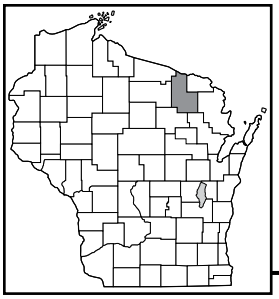
SUMMARY OF FINDINGS
The post-development abundance for all sizes of wild brook trout declined 13% and wild brown trout declined 77% (Table 32). The total biomass for all sizes of wild brook trout increased 3% and wild brown trout increased 15%. A decline in the abundance of age 0 trout (<4 inches) may have been responsible for the overall decline in the abundance of both trout species.

The post-development abundance for both species of legal-size trout (≥7 inches) increased 28%. This included a 6% increase in legal-size brook trout and a 187% increase in legal-size brown trout (Table 32). The abundance of both species of trout ≥9 inches increased 86%, however, 89% of the increase was due to the large increase in brown trout abundance.

SOURCE DOCUMENT
D. Brum, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 10 Jan 2000.

Table 32. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild age 0+ brook trout and brown trout in the Elvoy Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Average	Post-dev. Average	Percent Change
Total number of trout per mile	Brook	8,960	7,755	-13
	Brown	3,254	759	-77
	Combined	12,214	8,514	-30
Number of trout per mile <4 inches	Brook	7,736	6,490	-16
	Brown	2,908	367	-87
	Combined	10,644	6,857	-36
Number of trout per mile >7 inches	Brook	110	117	6
	Brown	15	43	187
	Combined	125	160	28
Number of trout per mile >9 inches	Brook	12	14	17
	Brown	10	27	170
	Combined	22	41	86
Pounds of trout per mile	Brook	122	126	3
	Brown	38	44	16
	Combined	160	170	6



ELVOY CREEK 2

Forest County
Wild Brook Trout and Wild Brown Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 9.6 miles including 9.6 miles of trout water
Average Width: 36.1 ft
pH: 6.6
Total Alkalinity: 51 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
The creek channel was excavated and single and double whole logs and boulders were added.

STUDY PERIOD AND DESIGN
There was 0.29 mile treatment zone with no reference zone. The pre-development surveys of the trout population were made August 1993 and July 1994. The habitat development occurred September 1994. The post-development trout population surveys were made July 1995-96.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Steve AveLallemant and David Brum.

SUMMARY OF FINDINGS
The average post-development abundance for all sizes of wild brook trout declined 40%; wild brown trout declined 36% (Table 33). The average biomass of wild brook trout declined 10% but biomass of wild brown trout increased 71%. The decline in abundance of age 0 trout (<4 inches) may have been responsible for the overall decline in abundance of both trout species.

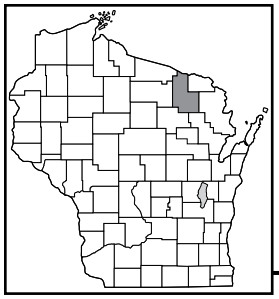
The average post-development abundance of legal-size trout (≥7 inches) increased 121%. This included a 105% increase in legal-size brook trout and a 194% increase in legal-size brown trout (Table 33). The average abundance of trout ≥9 inches increased 500% and included a 378% increase in brook trout and a 625% increase in brown trout.

The average abundance for all trout species combined declined 40% following habitat development, however, the average biomass stayed the same because of the increase in abundance of legal-size trout.

SOURCE DOCUMENT
D. Brum, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 10 Jan 2000.

Table 33. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild age 0+ brook trout and brown trout in the Elvoy Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Average	Post-dev. Average	Percent Change
Total number of trout per mile	Brook	4,232	2,526	-40
	Brown	222	141	-36
	Combined	4,454	2,667	-40
Number of trout per mile <4 inches	Brook	2,686	1,077	-60
	Brown	26	0	-100
	Combined	2,712	1,077	-60
Number of trout per mile ≥7 inches	Brook	95	195	105
	Brown	18	53	194
	Combined	112	248	121
Number of trout per mile ≥9 inches	Brook	9	43	378
	Brown	4	29	625
	Combined	12	72	500
Pounds of trout per mile	Brook	123	111	-10
	Brown	16	28	75
	Combined	139	139	0



ELVOY CREEK 3

Forest County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 9.6 miles including 9.6 miles trout water
Average Width: 36.1 ft
pH: 6.6
Total Alkalinity: 51 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were skyhook boom covers, wing deflectors, and boulders added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.25 mile treatment zone with one 0.07 mile reference zone immediately downstream. The pre-development surveys of trout populations in both study zones were made in July 1984-86. The habitat development occurred from August to September 1986 and post-development trout surveys were made in July 1987-93.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Lloyd Andrews, Steve AveLallemant, and David Brum.

SUMMARY OF FINDINGS
The average abundance of both brook trout and brown trout declined in the treatment zone but increased in the reference zone. The proportional decline was greater for brown trout than for brook trout. The average abundance of brook trout declined 38% in the treatment zone but increased 29% in the reference zone (Table 34). The average abundance of brown trout declined 46% in the treatment zone but increased 113% in the reference zone.

The average density of both wild brook trout and wild brown trout ≥8 inches increased in the treatment zone. The proportional increase was greater for brown trout than for brook trout. In Elvoy Creek, this disparity may be the result of the difference in the minimum legal size for brook trout (8 inches) compared to brown trout (12 inches) since 1990. The average abundance of brook trout ≥8 inches increased 335% in the treatment zone and increased 40% in the reference zone (Table 34). The average abundance of brown trout ≥8 inches increased 823% in the treatment zone but declined 80% in the reference zone.

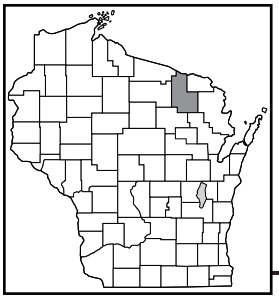
The average post-development abundance of both brook trout and brown trout ≥12 inches increased in the treatment zone but either declined or were absent in the reference zone. The proportional increase in the treatment zone was greater for brown trout than for brook trout. Brook trout ≥12 were absent from both study zones before habitat development, however, following development the average abundance in the treatment zone increased 1000%! Legal-size brown trout (≥12 inches) increased 10,400% in the treatment zone but declined 100% in the reference zone.

The average abundance of both trout species combined declined 42% in the treatment zone but increased 57% in the reference zone following habitat development. The combined average biomass increased 115% in the treatment zone but declined 13% in the reference zone (Table 34). The 615% increase in average abundance of trout ≥8 inches in the treatment zone offsets the lost biomass represented by a 45% decline in average abundance of trout ≤7.9 inches. The average abundance of trout ≥8 inches declined 72% in the reference zone while the average abundance of trout ≤7.9 inches increased 57% in the reference zone.

SOURCE DOCUMENTS
S. AveLallemant and D. Brum, Wisconsin Department of Natural Resources, to waters file, intradepartmental memo. No Date.

D. Brum, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 10 Jan 2000.

continued on page 36

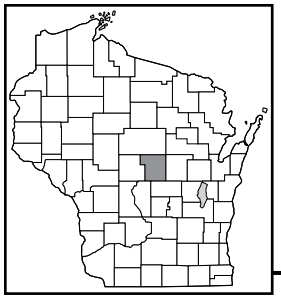


ELVOY CREEK 3 (continued)

Forest County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

Table 34. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild age 0+ brook trout and brown trout in the Elvoy Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Study Zone	Pre-development Avg.	Post-development Avg.	Percent Change
Brook	Total number of trout per mile	TZ	5,498	3,415	-38
		RZ	5,074	6,555	29
	Number of trout per mile ≤7.9 inches	TZ	5,463	3,315	-39
		RZ	3,766	6,535	74
	Number of trout per mile ≥8 inches	TZ	23	100	335
		RZ	15	21	40
	Number of trout per mile ≥12 inches	TZ	0	10	1,000
		RZ	0	0	0
	Pounds of trout per mile	TZ	105	120	14
		RZ	118	124	5
Brown	Total number of trout per mile	TZ	4,672	2,508	-46
		RZ	2,514	5,343	113
	Number of trout per mile ≤7.9 inches	TZ	4,642	2,222	-52
		RZ	2,315	5,305	129
	Number of trout per mile ≥8 inches	TZ	31	286	823
		RZ	199	39	-80
	Number of trout per mile ≥12 inches	TZ	0	104	10,400
		RZ	26	0	-100
	Pounds of trout per mile	TZ	67	248	270
		RZ	142	101	-29
Combined	Total number of trout per mile	TZ	10,170	5,923	-42
		RZ	7,588	11,898	57
	Number of trout per mile ≤7.9 inches	TZ	10,105	5,537	-45
		RZ	6,081	11,840	95
	Number of trout per mile ≥8 inches	TZ	54	386	615
		RZ	214	60	-72
	Number of trout per mile ≥12 inches	TZ	0	114	11,400
		RZ	26	0	-100
	Pounds of trout per mile	TZ	172	369	115
		RZ	260	225	-13



EMMONS CREEK

Portage County
Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 5.8 miles including 5.8 miles of trout water
Average Width: 18.0 ft
pH: 8.2
Total Alkalinity: 186 ppm
Base Flow Stream Discharge: 19.2 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
There were boom covers, wing deflectors, brush bundles, half-logs, and rock riprap added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.1 mile treatment zone with one 0.2 mile reference zone located immediately downstream. A pre-development trout population survey was done in April 1984. Habitat development occurred during May and June 1984. The post-development trout population surveys were made in April 1986 and 1990. During the summer 1985 to enhance trout habitat, fisheries management crews removed dead elm snags, positioned in-stream log deflectors, and constructed brush bundles throughout the upper 5.0 miles of Emmons Creek. This development included both study zones and represents an unknown impact.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principle investigator for this project was Ed Avery.

SUMMARY OF FINDINGS
The post-development abundance of wild brown trout declined in both study zones but the decline was proportionately greater in the treatment zone (Table 35). Trout abundance declined 32% in the reference zone and declined 48% in the treatment zone.

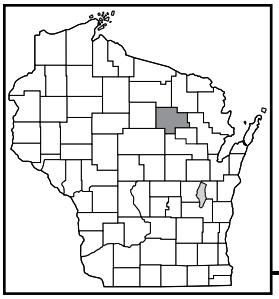
In both study zones, the post-development abundance of legal-size brown trout (≥6 inches) and brown trout ≥9 inches followed trends similar to those of the total population. Legal-size brown trout declined 24% in the reference zone and declined 46% in the treatment zone (Table 35); Brown trout ≥9 inches declined 17% in the reference zone and declined 22% in the treatment zone.

Although formal creel surveys were not conducted, fishing pressure was observed to increase in the treatment zone following habitat improvement and through the drought years of 1988-89. This may explain the decline of legal-size trout in the treatment zone. If similar declines in legal-size trout in both study zones are assumed, a greater decline of the brown trout population in the treatment zone still remain a mystery.

SOURCE DOCUMENT
E.L. Avery, Wisconsin Department of Natural Resources, to J. Zimmerman, intradepartmental memo. 28 Nov 1990.

Table 35. *Abundance (number of trout per mile) of wild brown trout in the Emmons Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Population Characteristic	Study Zone	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	TZ	6,889	3,612	-48
	RZ	6,086	4,148	-32
Number of trout per mile ≥6 inches	TZ	2,856	1,534	-46
	RZ	2,403	1,816	-24
Number of trout per mile ≥9 inches	TZ	411	322	-22
	RZ	462	383	-17



EVERGREEN RIVER

Langlade County
Wild Brook Trout and Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 8.2 miles including 8.2 miles of trout water
Average Width: 18 ft
pH: 7.7
Total Alkalinity: 130 ppm
Base Flow Stream Discharge: 15 to 18 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
There were skyhook boom covers added to the river.

STUDY PERIOD AND DESIGN
There was one 0.31 mile treatment zone with a 0.14 mile reference zone split above and below the treatment zone. A pre-development trout population survey was conducted in June 1981 in both study zones. Skyhook boom covers were installed in the treatment zone July 1981 and post-development population surveys were conducted in June 1984 and 1986. The average stream width and depth were measured before and after habitat development.

PROJECT COST
The cost of this project was approximately $63,360/mile of habitat development.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Max Johnson.

SUMMARY OF FINDINGS
The response of the trout population to habitat development was mixed. For both trout species combined the post-development abundance declined 30% but the abundance of legal-size trout (≥6 inches) increased 12% and total biomass increased 29% (Table 36).

Brook trout abundance and biomass responded negatively to habitat development while the opposite was true for brown trout. In the treatment zone, the post-development abundance of brook trout declined 61% and biomass declined 64% (Table 36). This is in contrast to the reference zone where post-development abundance of brook trout declined 24% and biomass declined 36%. The post-development abundance and biomass of brown trout in the treatment zone increased 257% and 1,100%, respectively, as opposed to increases of only 91% and 52% in the reference zone.

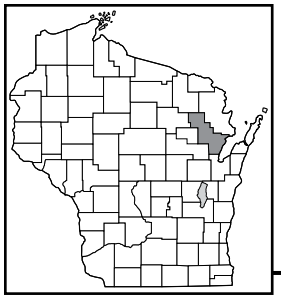
Legal-size brook trout (≥6 inches) declined 70% in the treatment zone and 25% in the reference zone (Table 36). The abundance of legal-size brown trout increased 1,362% in the treatment zone and 67% in the reference zone.

In both study zones, habitat development reduced the average width of the stream by 57% (from 27 ft to 11.5 ft) and increased the average depth by 50% (from 7.0 inches to 13.9 inches). Although not quantitatively measured, the amount of gravel substrate was reported to have doubled.

SOURCE DOCUMENT
M. Johnson, Wisconsin Department of Natural Resources, to L. Claggett, intradepartmental memo. 5 Feb 1988.

Table 36. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and brown trout in the Evergreen River treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development*

Trout Species	Population Characteristic	Study Zone	1981 Pre-dev. Value	1984 Post-dev. Value	1986 Post-dev. Value	Post-dev. Average	Percent Change
Brook	Total number of trout per mile	TZ	1,479	787	358	572	-61
		RZ	2,000	1,536	1,486	1,511	-24
	Number of trout per mile ≥6 inches	TZ	223	65	71	68	-70
		RZ	200	57	243	150	-25
	Pounds of trout per mile	TZ	90	40	24	32	-64
		RZ	120	66	88	77	-36
Brown	Total number of trout per mile	TZ	94	271	400	336	257
		RZ	250	421	536	478	91
	Number of trout per mile ≥6 inches	TZ	13	113	268	190	1,362
		RZ	64	50	164	107	67
	Pounds of trout per mile	TZ	6	47	98	72	1,100
		RZ	25	24	51	38	52
Combined	Total number of trout per mile	TZ	1,573	1,058	758	908	-42
		RZ	2,250	1,957	2,022	1,990	-12
	Number of trout per mile ≥6 inches	TZ	236	178	339	258	9
		RZ	264	107	407	257	-3
	Pounds of trout per mile	TZ	96	87	122	104	8
		RZ	145	90	138	114	-21



FIRST SOUTH BRANCH OCONTO RIVER

Oconto County
Wild Brook and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 18.3 miles including 11.7 miles of trout water
Average Width: 15 ft
pH: 7.4
Total Alkalinity: 125 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were 30 bank cover/current deflectors and 20 boulders added to the river.

STUDY PERIOD AND DESIGN
There was one 0.61 mile treatment zone with no reference zone. The pre-development survey of age I+ trout was completed in June 1978. No age 0's were collected. Habitat development began in 1981 and was completed in September 1983. In 1990, category 4 trout fishing regulations were implemented; a daily bag limit of 3 trout with a minimum size of 12 inches for brown trout and 8 inches for brook trout. Post-development trout population surveys of trout larger than 3 inches were conducted annually in late July and early August from 1990-96.

No trout population data providing pre-development versus post-development comparisons in the treatment zone is cited in the source document. Post-development trout population estimates included some age 0 individuals in the 3 inch group. However, pre- and post-development comparisons were made only between populations of age I+ (4 inches or larger). The pre-development population was compared to the 7 year post-development average.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principle investigators on this project were Russ Heizer and Cliff Sebero.

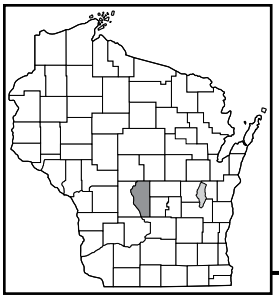
SUMMARY OF FINDINGS
Response of the trout population to habitat development was disappointing. Total abundance of trout declined 64% and included declines in both brook trout and brown trout populations (Table 37). Abundance of brook trout ≥8 inches increased 59% as compared to a 40% decline in similar size brown trout. Total standing stock of trout declined 45% following habitat development.

SOURCE DOCUMENTS
R. Heizer Wisconsin Department of Natural Resources, intradepartmental files, Peshtigo, WI.

C. Sebero, Wisconsin Department of Natural Resources, intradepartmental files, Peshtigo, WI.

Table 37. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and brown trout in the First South Branch Oconto River treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	1978 Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	Brook	1,623	579	-64
	Brown	7	6	-14
	Combined	1,630	585	-64
Number of trout per mile ≥8 inches	Brook	41	65	59
	Brown	5	3	-40
	Combined	46	68	48
Number of trout per mile ≥12 inches	Brook	0	0	0
	Brown	0	2	200
	Combined	0	2	200
Pounds of trout per mile	Brook	108	58	-46
	Brown	2	2	0
	Combined	110	60	-45



FORDHAM CREEK

Adams County
Wild Brook Trout, Wild Brown Trout, and Domestic Rainbow Trout
Category 5 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 6.0 miles including 6.0 miles of trout water
Average Width: 13.0 ft
pH: 7.9
Total Alkalinity: 192 ppm
Base Flow Stream Discharge: 11.6 cfs
Gradient: 8.9 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were boom covers and brush bundles added to the creek and stream bank debrushing was done.

STUDY PERIOD AND DESIGN
There was one 0.15 mile treatment zone with no reference zone. A pre-development trout population survey was done in the treatment zone May 1995. Habitat development occurred during the summer 1995 and a post-development survey of the trout population was made June 1997. Category 5 trout fishing regulations were in effect throughout the study that included a daily bag and size limit of 5 trout under 8 inches, or a daily bag and size limit of 4 trout under 8 inches and 1 trout over 12 inches.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Scot Ironside, Dale Kufalk, and Dave Paynter.

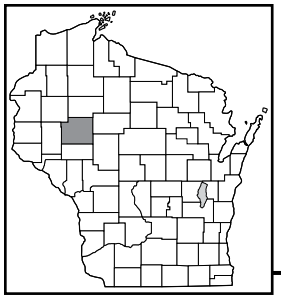
SUMMARY OF FINDINGS
The abundance and biomass of all three trout species (brook trout, brown trout, and rainbow trout) benefited from habitat improvement. Brook trout was the most abundant species and showed a post-development increase of 33%; the post-development abundance of brown trout increased 132% and post-development abundance of rainbow trout increased 43% (Table 38).

On Fordham Creek, there is a protected slot size range of 8.0-11.9 inches. Angler harvest is restricted to 4 or 5 fish below the slot and 1 fish above the slot. The post-development abundance of brook trout within the slot size range declined 17% but increased 115% for brown trout and 52% for rainbow trout (Table 38). The post-development abundance for all three trout species increased 193%, however, the 257% post-development increase for brown trout ≥12 inches accounted for most of this increase. There were no brook trout ≥12 inches in the creek before or after habitat development and the density of rainbow trout ≥12 inches did not change.

SOURCE DOCUMENT
D. Paynter, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 1 Mar 2000.

Table 38. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of age I+ brook trout, brown trout, and rainbow trout in the Fordham Creek treatment zone (TZ) before (pre) and after (post) habitat development. N/A = data not available.*

Population Characteristic	Trout Species	Pre-dev. Value	Post-dev. Value	Percent Change
Total number of trout per mile	Brook	588	780	33
	Brown	103	239	132
	Rainbow	82	117	43
	Combined	773	1,136	47
Number of trout per mile <8 inches	Brook	431	650	51
	Brown	34	61	79
	Rainbow	48	68	42
	Combined	513	779	52
Number of trout per mile 8 to 11.9 inches	Brook	157	130	-17
	Brown	48	103	115
	Rainbow	27	41	52
	Combined	232	274	18
Number of trout per mile ≥12 inches	Brook	0	0	0
	Brown	21	75	257
	Rainbow	7	7	0
	Combined	28	82	193
Pounds of trout per mile	Brook	33.1	64.7	95
	Brown	18.1	96.3	432
	Rainbow	N/A	N/A	N/A
	Combined	51.2	161	214



HAY CREEK

Chippewa County
Wild Brook Trout, Wild Brown Trout, and Domestic Brown Trout
Category 3 Trout Fishing Regulation
Class II Trout Stream

STOCKING PROTOCOL
The stocking protocol for this creek included stocking age 0 brown trout in the fall at the lower boundary of the treatment zone.

STREAM DESCRIPTION
Total Length: 6.0 miles including 6.0 miles of trout water
Average Width: 8 ft
pH: 6.8
Total Alkalinity: 44 ppm
Base Flow Stream Discharge: 10 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
The primary objective of the habitat development was to improve natural reproduction of trout in this predominantly sand-bottomed creek. As a result, a sediment trap was added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.87 mile treatment zone with one 0.25 mile reference zone upstream of the treatment zone. A sediment trap (avg. width 19.4 ft, avg. depth 3.0 ft) was excavated in the upper 260 ft of the treatment zone in November 1985. The sediment trap was re-excavated in September 1988 (length 270 ft, avg. width 21.9 ft, average depth 3.6 ft). The physical characteristics (width, depth, substrate composition, and stream discharge) of both study zones were measured in September 1985 and June 1989. Trout population surveys were conducted in August 1984-90 in both study zones.

This study was part of a larger investigation of sediment traps and artificial gravel riffles to improve trout reproduction involving Chaffee Creek (1984-91) and Waupee Creek (1986-91).

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Ed Avery.

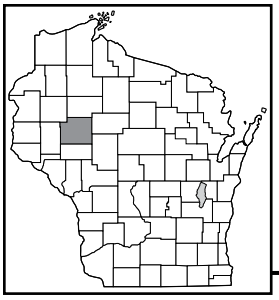
SUMMARY OF FINDINGS
The post-development response of the trout population was disappointing. In the treatment zone, abundance of brook trout increased 105% and in the reference zone abundance increased 691% (Table 39). In both study zones, the post-development abundance of brown trout declined but the decline was proportionately greater in the treatment zone.

Natural reproduction of trout was not facilitated as a result of excavating a sediment trap. The post-development abundance of age 0 brook trout and age 0 brown trout was proportionately greater in the reference zone than in the treatment zone. The combined abundance for both species of age 0 trout declined 39% in the treatment zone but increased more than 11 fold in the reference zone (Table 39).

The interpretation of post-development physical changes in the treatment zone was complicated by a 32% reduction in stream discharge from 1985 to 1999 (Table 40). The average width of the stream declined 16% in the treatment zone but remained the same in the reference zone. The average depth of the stream declined in both study zones but the decline was proportionately greater in the treatment zone. The post-development abundance of gravel substrate (percent transects with gravel and the percentage of sites within transects with gravel) increased more in the reference zone. Overall, habitat development failed to show any positive effect upon the physical characteristics measured.

SOURCE DOCUMENT
Avery, Ed L. 1996. Evaluations of sediment traps and artificial gravel riffles constructed to improve reproduction of trout in three Wisconsin streams. *North American Journal of Fisheries Management* 16:282-293.

continued on page 42



HAY CREEK (continued)

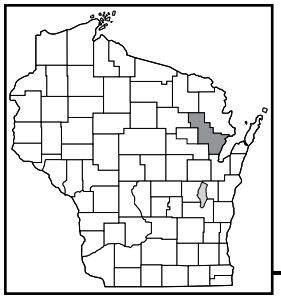
Chippewa County
Wild Brook Trout, Wild Brown Trout, and Domestic Brown Trout
Category 3 Trout Fishing Regulation
Class II Trout Stream

Table 39. *Abundance (number of trout per mile) of wild brook trout and wild and domestic brown trout in the Hay Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Study Zone	Pre-development Avg.	Post-development Avg.	Percent Change
Brook	Total number of trout per mile	TZ	81	166	105
		RZ	32	243	691
	Number of age 0 trout per mile	TZ	29	106	266
		RZ	16	172	975
	Number of age I+ trout per mile	TZ	52	60	15
		RZ	16	71	344
Brown	Total number of trout per mile	TZ	248	116	-53
		RZ	56	32	-43
	Number of wild, age 0 trout per mile	TZ	187	26	-86
		RZ	0	8	800
	Number of age I+ trout per mile	TZ	61	90	48
		RZ	56	24	-57
Combined	Total number of trout per mile	TZ	329	282	-14
		RZ	88	275	213
	Number of wild, age 0 trout per mile	TZ	216	132	-39
		RZ	16	180	1,025
	Number of age I+ trout per mile	TZ	113	150	33
		RZ	72	95	32

Table 40. *Physical characteristics of the Hay Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

	RZ			TZ		
Characteristics	Pre-development Value	Post-development Value	Percent Change	Pre-development Value	Post-development Value	Percent Change
Stream discharge (cubic feet per second)				7.8	5.3	-32
Average width (feet)	14.4	14.4	0	13.4	11.2	-16
Average depth (feet)	1.2	1	-17	1.2	0.8	-33
Percentage of transects with gravel	36	71	35	70	73	3
Percentage of sites within transects with gravel	8	23	15	23	38	15



HAY CREEK

Oconto County
Wild Brook Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 6.1 miles including 6.1 miles of trout water
Average Width: 6 ft
pH: 7.3
Total Alkalinity: 123 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
Stream bank debrushing was done to the creek.

STUDY PERIOD AND DESIGN
There was one 0.19 mile treatment zone with an adjacent downstream 0.19 mile reference zone. The brook trout in the study zones were surveyed in June 1982, 2 months before stream banks were cleared of woody vegetation. The age 0 brook trout were common in the study zones but were not estimated in June 1982 or in July 1984, when the first post-development survey was made. These data are reported in Hunt (1988, p. 27).

In 1990, new trout angling regulations were implemented on Hay Creek. These included a daily bag limit of 5 trout and a minimum size limit of 7 inches. Subsequent post-development surveys were made in the study zones in August 1990-92. The age 0 brook trout were estimated during these surveys but were not included in the pre- and post-development comparisons to maintain consistency.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Russ Heizer and Thomas Thuemler.

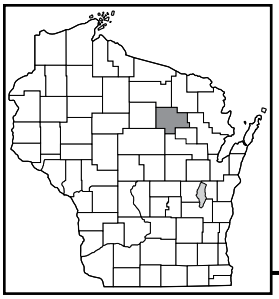
SUMMARY OF FINDINGS
The results from the post-development surveys of brook trout in the 2 study zones were disappointing (Table 41). The post-development abundance of age I+ brook trout declined 49% in the treatment zone and 33% in the reference zone for a net loss of 16%. The post-development abundance of legal-size brook trout (≥7 inches in the 1990's) increased 93% in the treatment zone, slightly better than the 74% increase seen in the reference zone. The post-development biomass increased 2% in the treatment zone and also increased 32% in the reference zone.

SOURCE DOCUMENTS
R. Heizer, Wisconsin Department of Natural Resources, to E. Avery, personal communication. 30 Jan 2001.

Hunt, R.L. 1988. A compendium of 45 trout stream habitat development evaluations in Wisconsin during 1953-85. Wisconsin Department of Natural Resources *Technical Bulletin* 162:1-80.

Table 41. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of age I+ brook trout in the Hay Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Population Characteristic	Study Zone	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	TZ	1,040	531	-49
	RZ	1,000	671	-33
Number of trout per mile ≥7 inches	TZ	90	174	93
	RZ	116	202	74
Pounds of trout per mile	TZ	60	61	2
	RZ	56	74	32



HUNTING RIVER 1

Langlade County
Wild and Domestic Brook Trout, and Wild and Domestic Brown Trout
Pre-1990 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 15.6 miles including 15.6 miles of trout water
Average Width: 44 ft
pH: 7.4
Total Alkalinity: 85 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were skyhook bank covers, current deflectors, and boulder retards added to the river.

STUDY PERIOD AND DESIGN
There was one 0.70 mile treatment zone with no reference zone. All of the trout in the treatment zone were surveyed in June 1979 and habitat development occurred in August 1979. The post-development surveys of the trout population occurred in 1982 and 1985. The abundance and biomass data in the source document only report data on trout 6 inches or larger. All trout 14 inches or larger were determined to be wild, as were most trout 6-10 inches and trout 10 inches or larger. There were no changes in physical features of the treatment zone reported in the source document.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Al Hauber.

SUMMARY OF FINDINGS
The post-development abundance and biomass of brook trout ≥6 inches declined 8% and 4%, respectively (Table 42). However, the post-development abundance and biomass of similar size brown trout increased 47% and 81%, respectively. Although the abundance and biomass of both trout species combined showed an increase following habitat development, brown trout showed the greatest positive increase.

The habitat development proved particularly favorable to larger brown trout (Table 42). Only 1 brook trout ≥10 inches was present before habitat development and no brook trout ≥10 inches occurred after development. However, the abundance of brown trout ≥10 inches increased 141% after habitat development.

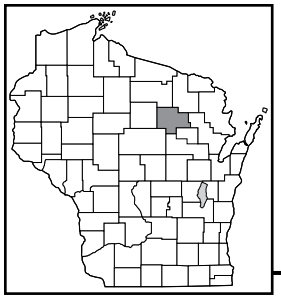
The most impressive proportional change was a 475% increase in the number of brown trout ≥14 inches following habitat development. Brown trout ≥6 inches accounted for 70% of the combined pre-development biomass of 83 pounds per mile and 81% of the combined post-development biomass of 129 pounds per mile (Table 42).

SOURCE DOCUMENT
A.B, Hauber, Wisconsin Department of Natural Resources, to R.L. Hunt, personal communication. 4 Jun 1986.

Table 42. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild and domestic brook trout and brown trout in the Hunting River treatment zone (TZ) station 1 before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Value	Post-dev. Average	Percent Change
Number of trout per mile ≥6 inches	Brook	166	152	-8
	Brown	223	328	47
	Combined	389	480	23
Number of trout per mile ≥10 inches	Brook	1	0	-100
	Brown	27	65	141
	Combined	28	65	132
Number of trout per mile ≥14 inches	Brook	0	0	0
	Brown	4	23	475
	Combined	4	23	475
Pounds of trout per mile[a]	Brook	25	24	-4
	Brown	58	105	81
	Combined	83	129	54

[a] Pounds of trout per mile includes only trout ≥6 inches.



HUNTING RIVER 2

Langlade County
Wild and Domestic Brook Trout, and Wild and Domestic Brown Trout
Pre-1990 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 15.6 miles including 15.6 miles of trout water
Average Width: 44 ft
pH: 7.4
Total Alkalinity: 85 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were skyhook bank covers, current deflectors, and boulder retards added to the river.

STUDY PERIOD AND DESIGN
There was one 0.52 mile treatment zone with no reference zone. The trout in the treatment zone were surveyed in June 1979, 2 months before habitat development was started. The habitat development was completed the end of summer in 1979. The post-development trout population surveys were conducted in June 1982 and June 1985. The abundance and biomass data in the source document only report data on trout 6 inches or larger. All trout 14 inches or larger were determined to be wild, as were most trout 6-10 inches and trout 10 inches or larger. There were no changes in physical features of the treatment zone reported in the source document.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Al Hauber.

SUMMARY OF FINDINGS
The habitat development favored brown trout over brook trout. The post-development abundance of brook trout ≥6 inches declined 47% and biomass of brook trout ≥6 inches declined 51% (Table 43). Conversely, the post-development abundance and biomass of brown trout ≥6 inches increased 42% and 77%, respectively. A brook trout to brown trout ratio of 1:1 before habitat development changed to a ratio of 1:2.3 after development.

There were no brook trout ≥10 inches present in the treatment zone before habitat development, but 3 per mile were present afterwards. The post-development abundance of brown trout ≥10 inches increased 33% (Table 43). In addition, an impressive 160% post-development abundance increase of brown trout ≥14 inches also occurred.

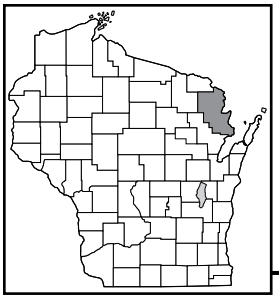
Brown trout ≥6 inches accounted for 64% of the combined pre-development biomass of 102 pounds per mile and 86% of the combined post-development biomass of 133 pounds per mile (Table 43).

SOURCE DOCUMENT
A.B, Hauber, Wisconsin Department of Natural Resources, to R.L. Hunt, personal communication. 4 Jun 1986.

Table 43. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild and domestic brook trout and brown trout in the Hunting River treatment zone (TZ) station 2 before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Value	Post-dev. Average	Percent Change
Number of trout per mile ≥6 inches	Brook	208	111	-47
	Brown	212	300	42
	Combined	420	411	-2
Number of trout per mile ≥10 inches	Brook	0	3	300
	Brown	46	61	33
	Combined	46	64	39
Number of trout per mile ≥14 inches	Brook	0	0	0
	Brown	10	26	160
	Combined	10	26	160
Pounds of trout per mile[a]	Brook	37	18	-51
	Brown	65	115	77
	Combined	102	133	30

[a] Pounds of trout per mile includes only trout ≥6 inches.



K.C. CREEK

Marinette County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 6.7 miles including 6.0 miles of trout water
Average Width: 12 ft
pH: 7.0
Total Alkalinity: 106 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were 29 bank covers, 15 wing deflectors, and 100 ft of riprap added to the creel.

STUDY PERIOD AND DESIGN
There was one 0.76 mile treatment zone with no reference zone. In June 1976, age I+ trout were surveyed in the treatment zone prior to initiation of habitat development that was completed in 1978. A post-development survey of trout was made in August 1982 and these data were reported in Hunt (1988, p.30). The additional post-development surveys of trout were made in July 1983, and July 1990-92. In 1990, new trout fishing regulations (category 4) were implemented. These regulations were a daily bag limit of 3 trout with the minimum size for brown trout being 12 inches and the minimum size for brook trout being 8 inches. The change in average width and surface area of the treatment zone were quantified in Hunt (1988) and for convenience are restated below. No additional measurements of the physical features in the treatment zone were made.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Russ Heizer and Cliff Sebero.

SUMMARY OF FINDINGS
Following habitat development, abundance of age I+ brook trout declined 18% and age I+ brown trout remained unchanged. For both species combined there was a 11% decline in post-development abundance (Table 44).

The abundance of legal-size brook trout (≥8 inches) declined 42% in response to habitat development and abundance of legal-size brown trout (≥12 inches) declined 4%. For both species combined, there was a 33% decline in legal-size trout abundance (Table 44).

There was a decline in trout standing stock following habitat development. A 34% decline in biomass of brook trout was accompanied by a 5% decline in biomass of brown trout. For both species combined, biomass declined 19% after habitat development (Table 44).

The average width of the treatment zone decreased 31% after development (from 16.0 ft to 11.1 ft) and surface area decreased from 1.47 acres to 1.02 acres.

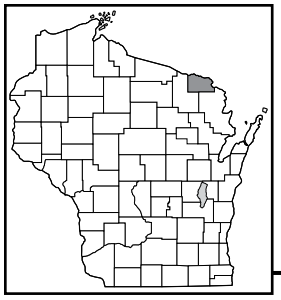
SOURCE DOCUMENTS
R. Heizer, Wisconsin Department of Natural Resources, to E. Avery, personal communication. 30 Jan 2001.

C. Sebero, Wisconsin Department of Natural Resources, to E. Avery, personal communication. 9 Dec 1999.

Hunt, R.L. 1988. A compendium of 45 trout stream habitat development evaluations in Wisconsin during 1953-1985. Wisconsin Department of Natural Resources *Technical Bulletin* 162:1-80.

Table 44. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and brown trout in the K.C. Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	Brook	252	206	-18
	Brown	171	171	0
	Combined	423	377	-11
Number of trout per mile ≥8 inches	Brook	91	53	-42
	Brown	63	87	38
	Combined	154	140	-9
Number of trout per mile ≥12 inches	Brook	0	4	400
	Brown	28	27	-4
	Combined	28	31	11
Pounds of trout per mile	Brook	50	33	-34
	Brown	58	55	-5
	Combined	108	88	-19



LAMONTANGUE CREEK

Florence County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 7.7 miles including 7.7 miles of trout water
Average Width: 8 ft
pH: 7.1
Total Alkalinity: 119 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were 35 bank covers and 150 ft of brush bundle added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.4 mile treatment zone with no reference zone. The trout population surveys were done in August 1979 before habitat development and in August 1987, 1990, and 1991 following habitat development. Habitat development began in 1980 and was completed in September 1983. In 1990, new trout fishing regulations (category 4) were implemented. These regulations were a daily bag limit of 3 trout with the minimum size for brown trout being 12 inches and the minimum size for brook trout being 8 inches. Additional trout surveys made in August 1992 and August 1995 were not included in the analyses because they did not include age 0 fish.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Russ Heizer and Cliff Sebero.

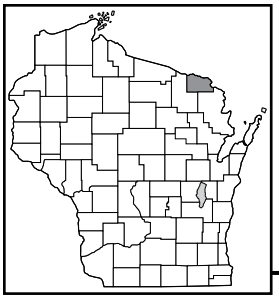
SUMMARY OF FINDINGS
The response of the brook trout population to habitat development was moderately successful. Although the total abundance of brook trout after habitat development declined 8% and biomass declined 9%, the post-development abundance of legal size brook trout (≥8 inches) increased 76% (Table 45).

Brown trout were only present following habitat development. However, the average post-development abundance of 3 trout per mile was of little consequence relative to habitat development.

SOURCE DOCUMENT
R. Heizer, Wisconsin Department of Natural Resources, to E. Avery, personal communication. 30 Jan 2001.

Table 45. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of trout in the Lamontangue Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	Brook	2,004	1,843	-8
	Brown	0	3	300
	Combined	2,004	1,846	-8
Number of trout per mile ≥8 inches	Brook	55	97	76
	Brown	0	1	100
	Combined	55	98	78
Number of trout per mile ≥12 inches	Brook	0	0	0
	Brown	0	1	100
	Combined	0	1	100
Pounds of trout per mile	Brook	81	74	-9
	Brown	0	1	100
	Combined	81	75	-7



LEPAGE CREEK

Florence County
Wild Brook Trout
Category 1 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 4.5 miles including 4.5 miles of trout water
Average Width: 5 ft
pH: 7.1
Total Alkalinity: 132 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were 2 bank cover/current deflectors, 3 boom covers, and 6 digger-logs added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.26 mile treatment zone with a 0.16 mile reference zone upstream from the treatment zone. The age I+ brook trout were surveyed in both zones June 1982. The habitat development occurred in summer 1984. In 1990, new trout angling regulations were implemented. They included a daily bag limit of 10 brook trout with no size limit (category 1). The post-development surveys were made in August 1990-92.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Russ Heizer and Cliff Sebero.

SUMMARY OF FINDINGS
The average post-development abundance of brook trout increased in both the treatment zone and reference zone but proportionally the increase was greater in the reference zone (Table 46). The average abundance of brook trout increased 33% in the treatment zone and 51% in the reference zone.

The post-development abundance of "quality-size" brook trout (trout ≥7 inches) also increased in both study zones. However, for these "quality-size" trout, proportional increases were greater in the treatment zone. The average post-development abundance of brook trout ≥7 inches increased 132% in the treatment zone and 26% in the reference zone (Table 46).

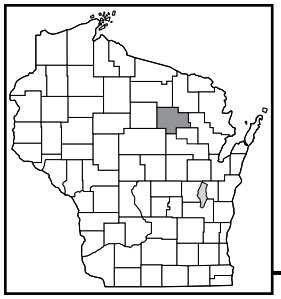
The total biomass of brook trout increased 61% in the treatment zone and 46% in the reference zone (Table 46). This may have been in response to the increase in abundance of larger size fish.

SOURCE DOCUMENTS
R. Heizer, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. No Date.

C. Sebero, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. No Date.

Table 46. *Abundance (number of trout per mile) of age I+ brook trout in the Lepage Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development*

Population Characteristic	Study Zone	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	TZ	483	644	33
	RZ	311	471	51
Number of trout per mile ≥7 inches	TZ	65	151	132
	RZ	50	63	26
Pounds of trout per mile	TZ	36	58	61
	RZ	24	35	46



LITTLE EVERGREEN CREEK

Langlade County
Wild Brook Trout and Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 6.2 miles including 6.2 miles of trout water
Average Width: 7 ft
pH: 6.8
Total Alkalinity: 197 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
The stream bank was debrushed.

STUDY PERIOD AND DESIGN
There was a 0.50 mile treatment zone with no reference zone. The pre-development trout population survey in the treatment zone was conducted June 1980. The stream bank debrushing in the treatment zone began in the fall 1981 and was completed by the spring 1982. The post-development trout population survey was made July 1986. The average stream width and depth were measured before and after habitat development.

PROJECT COST
The cost of the project was approximately $3,617 including labor.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project was David Seibel and Max Johnson.

SUMMARY OF FINDINGS
Following habitat development, trout abundance increased 11% and trout biomass increased 4% (Table 47).

Wild brook trout responded negatively to habitat development. The post-development abundance and biomass for all sizes of brook trout declined 10% and 30%, respectively. The abundance of legal-size brook trout (≥6 inches) declined 43% but abundance of brook trout ≥8 inches remained the same (Table 47).

Conversely, wild brown trout responded positively to habitat development. The post-development abundance and biomass for all sizes of brown trout increased 286% and 273%, respectively. The abundance of legal -size brown trout (≥6 inches) increased 325% and abundance of brown trout ≥8 inches increased 400% (Table 47).

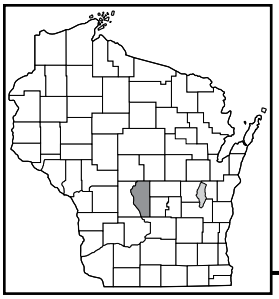
Physical changes in the treatment zone were dramatic. The stream was converted from a tag alder tunnel to an open meadow dominated by sedges and grasses. The average width of the stream was reduced by 5% (from 12.0 ft to 11.4 ft) and the average depth increased 7% (from 7 inches to 7.5 inches). The number of holes deeper than 1.5 ft increased 300% (from 2 to 8) and 2 holes exceeded 3 ft in depth.

In 1980, summer water temperatures were recorded for 60 days. A maximum daily water temperature of 59°F was recorded. Daily high water temperatures were generally less than 57°F. The stream bank debrushing may have increased water temperatures. This would have been desirable since cold water temperatures are believed to be a factor limiting production in this particular stream.

SOURCE DOCUMENT
M. Johnson, Wisconsin Department of Natural Resources, to L. Claggett, intradepartmental memo. 4 Feb 1988.

Table 47. *Abundance and biomass of wild brook trout and brown trout in the Little Evergreen Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Value	Post-dev. Value	Percent Change
Total number of trout per mile	Brook	1,171	1,058	-10
	Brown	87	336	286
	Combined	1,258	1,394	11
Number of trout per mile ≥6 inches	Brook	240	138	-43
	Brown	28	119	325
	Combined	268	257	-4
Number of trout per mile ≥8 inches	Brook	15	15	0
	Brown	13	65	400
	Combined	28	80	186
Pounds of trout per mile	Brook	82	57	-30
	Brown	11	40	273
	Combined	93	97	4



LITTLE ROCHE A CRI CREEK

Adams County
Wild Brook Trout and Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 13.3 miles including 7.3 miles of trout water
Average Width: 25 ft
pH: 7.6
Total Alkalinity: 106 ppm
Base Flow Stream Discharge: 28.1 cfs
Gradient: 6.2 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were boom covers, brush bundles, log retards, and wing deflectors added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.53 mile treatment zone with no reference zone. A pre-development trout population survey was made in the treatment zone July 1986. The habitat development occurred during summer 1987 and a post-development survey of the trout population was made July 1989.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Scot Ironside and David Paynter.

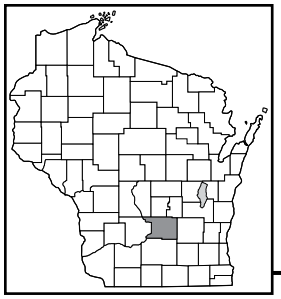
SUMMARY OF FINDINGS
Following habitat development, the abundance of all sizes of trout and abundance of legal-size trout (≥6 inches) increased for both brook trout and brown trout. However, proportionately the increases were greater for brook trout (Table 48). The post-development abundance of brook trout increased 161% and abundance of brown trout increased 33%.

The post-development abundance of legal-size brook trout (≥6 inches) increased 153% and legal-size brown trout (≥6 inches) increased 29%. The combined abundance of both trout species increased 156% following habitat development and legal-size trout (≥6 inches) increased 146% (Table 48).

SOURCE DOCUMENT
D. Paynter, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 1 Mar 2000.

Table 48. *Abundance (number of trout per mile) of age I+ brook trout and brown trout in the Little Roche A Cri Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Pre-dev. Value	Post-dev. Value	Percent Change
Brook	Total number of trout per mile	712	1,855	161
	Number of trout per mile ≥6 inches	394	997	153
Brown	Total number of trout per mile	36	48	33
	Number of trout per mile ≥6 inches	34	44	29
Combined	Total number of trout per mile	744	1,903	156
	Number of trout per mile ≥6 inches	424	1,041	146



LODI (SPRING) CREEK

Columbia County
Wild Brown Trout
Category 5 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
As of 1993 there were no stocking protocols for this creek.

STREAM DESCRIPTION
Total Length: 8.0 miles including 8.0 miles of trout water
Average Width: 28 ft
pH: 7.7
Total Alkalinity: 276 ppm
Base Flow Stream Discharge: 20-30 cfs
Gradient: 6.5 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were riprap, current deflectors, and instream boulders added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.38 mile treatment zone with a 0.5 mile reference zone immediately downstream (reference zone 2) and a 1.0 mile reference zone immediately upstream (reference zone 1). All spawning is believed to occur in a riffle area immediately above reference zone 1.

The pre-development trout population survey was conducted in October 1992 and the post-development population survey was conducted in October 1996. The habitat development was done in winter 1993-94. Category 5 trout fishing regulations remained constant throughout the study. These regulations include using only artificial bait, and a bag limit of 1 trout per day with a size limit of 15 inches.

PROJECT COST
The cost of the project was approximately $12 per ft of habitat restored (one streambank only).

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Tim Larson.

SUMMARY OF FINDINGS
The post-development abundance of wild brown trout declined in all 3 study zones. The greatest decline of 67% occurred in the treatment zone with corresponding declines of 62% in reference zone 2 and 26% in reference zone 1 (Table 49).

The post-development abundance of brown trout 12.0-14.9 inches and brown trout ≥15 inches increased in all study zones but failed to suggest a consistent advantage resulting from habitat development. For instance, brown trout in the 12.0-14.9 inch range showed a post-development increase of 162% in the treatment zone. This exceeded the 50% increase in reference zone 2, but was less than the 196% increase in reference zone 1 (Table 49). The post-development abundance of brown trout ≥15 inches increased 60% in the treatment zone but was less than the 175% increase in reference zone 2 and the 112% increase in reference zone 1.

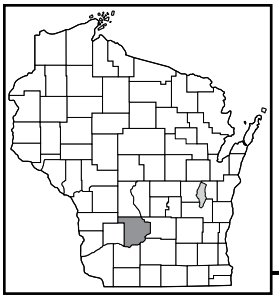
The post-development decrease in abundance of brown trout <7 inches (age 0) and brown trout in the 7.0-11.9 inch range (Table 49) suggest that consecutive years of poor natural reproduction may have been responsible for the decline in total population abundance following habitat development. The abundance of brown trout <7 inches declined 100% in reference zone 2, 99% in the treatment zone, and 68% in reference zone 1. An 8% increase of trout in the 7.0-11.9 inch range occurred in reference zone 1 but was accompanied with a 46% decrease in the treatment zone and a 54% decrease in reference zone 2.

The source document suggests that post-development increases in fishing pressure in the treatment zone along with increased handling mortalities may have reduced the post-developmental gain in abundance of larger trout. And even though habitat work has succeeded in stabilizing almost vertical, bare eroding banks (lessening the impact of cattle that have free access to the stream) and creating more instream habitat for trout, the solution to declining recruitment must be resolved before any improvement in the fishery can result.

SOURCE DOCUMENT
T. Larsen, Wisconsin Department of Natural Resources, to the Water File, intradepartmental memo. 17 Oct 1996.

Table 49. *Abundance (number of trout per mile) of wild brown trout in the Lodi Creek treatment zone (TZ), downstream reference zone (RZ 2), and upstream reference zone (RZ 1) before (pre) and after (post) habitat development.*

	RZ 2			TZ			RZ 1		
Population Characteristic	Pre-dev. Value	Post-dev. Value	Percent Change	Pre-dev. Value	Post-dev. Value	Percent Change	Pre-dev. Value	Post-dev. Value	Percent Change
Number of trout per mile <7 inches	142	0	-100	201	3	-99	458	145	-68
Number of trout per mile 7 to 11.9 inches	180	82	-54	180	98	-46	322	347	8
Number of trout per mile 12 to 14.9 inches	20	30	50	8	21	162	27	80	196
Number of trout per mile ≥15 inches	8	22	175	5	8	60	17	36	112
Total number of trout per mile	350	134	-62	394	130	-67	824	608	-26



MANLEY CREEK

Sauk County
Wild Brook Trout
Category 3 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 2.5 miles including 2.5 miles of trout water
Average Width: 6 ft
pH: 7.8
Total Alkalinity: 206 ppm
Base Flow Stream Discharge: 2 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
The streambank was debrushed and upstream wedge dams and cross-channel log revetments were added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.38 mile treatment zone with no reference zone. This trout stream habitat project was done as a cooperative effort with Wisconsin Power and Light Company on their property using youth work crews. The majority of the habitat work was completed June-August 1997. The pre-development surveys of wild brook trout ≥6 inches were done in May 1996 and the post-development surveys were done in June 1998. In addition, water temperatures above and below the treatment zone were continuously monitored from late July through October 1997.

PROJECT COST
None Provided.

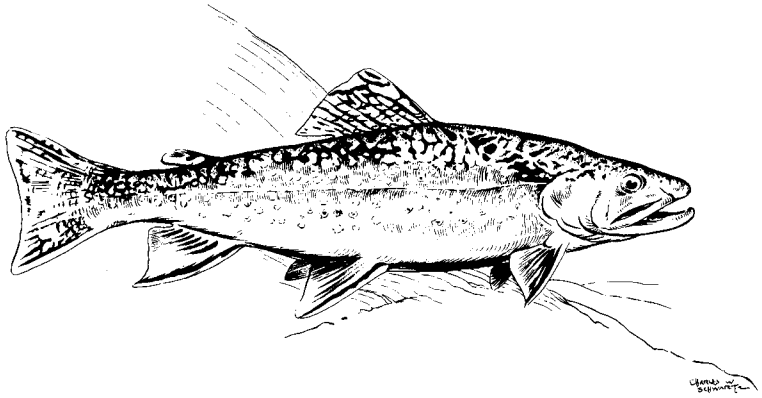
PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Tim Larson.

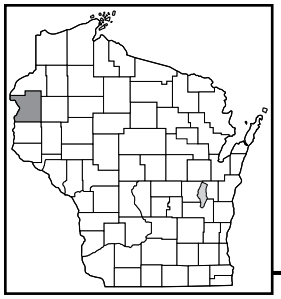
SUMMARY OF FINDINGS
The post-development abundance of wild brook trout ≥6 inches increased 202% (Table 50). The source document indicates no significant change in water temperature as a result of streambank debrushing. Although no seasonal pre-development data exists, the source document gives an average abundance of brook trout <6 inches surveyed in the fall from 1997-99 of 542 trout per mile.

SOURCE DOCUMENT
T. Larsen, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 5 Jan 2000.

Table 50. *Abundance (number of trout per mile) of wild brook trout in the Manley Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Value	Post-dev. Value	Percent Change
Number of trout per mile ≥6 inches	96	290	202
Number of trout per mile ≥10 inches	16	3	-81





McKENZIE CREEK

Polk County
Wild Brook Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 6.6 miles including 6.6 miles of trout water
Average Width: 10 ft
Total Alkalinity: 99 ppm
Base Flow Stream Discharge: 19 cfs
Gradient: 15 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were log bank covers, wing deflectors, rip-rap, brush mats, and half-logs added to the creek. In addition, debris was removed and there was selective streambank debrushing.

STUDY PERIOD AND DESIGN
There were two 0.19 mile treatment zones separated by 0.17 miles with no reference zones. Single-run electrofishing surveys of trout were conducted to evaluate the habitat development projects and pre- and post-development catch-per-efforts (CPE) were compared.

In treatment zone 1, the pre-development electrofishing surveys were conducted during 1975 and 1981 with habitat development occurring in 1983. The post-development surveys were done in 1986, 1987, and 1993.

In treatment zone 2, pre-development trout surveys were made in 1975 and 1986, followed by habitat development in 1987. The post-development surveys were done in 1987 and 1993.

Data for single-run electrofishing surveys done in both treatment zones in 1994, 1995, and 1998. These data are included in the source document but are not included in this report because wild brown trout transfers made to the stream in 1994-95 and beaver dam removal in 1995 negated their consideration. It should be noted that a remnant population of wild brook trout is also present in the stream, but only data on wild brown trout are included in this report.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Rick Cornelius.

SUMMARY OF FINDINGS
The wild brown trout populations increased in both treatment zones following habitat development. In treatment zone 1, fingerling abundance (<5 inches) decreased 28% but abundance of adults (≥5 inches) increased 77% (Table 51). The total abundance of all sizes of trout in increased 27% in treatment zone 1.

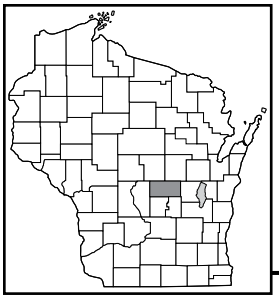
In treatment zone 2, post-development abundance of fingerlings and adults increased 71% and 44%, respectively. The total abundance of all sizes of trout increased 50% in treatment zone 2 (Table 51).

The source document indicates that the trout population in McKenzie Creek is suppressed by a lack of consistent recruitment from natural reproduction. Summer water temperatures in both treatment zone's exceed 70°F with some regularity and combined with cold winter water temperatures the inconsistent recruitment may be temperature related. In summer 1995 beaver dams were removed to help try alleviate temperature problems. Nevertheless, the trout population needs considerably more improvement before available habitat is fully utilized.

SOURCE DOCUMENT
R. Cornelius, Wisconsin Department of Natural Resources, to B. Smith, intradepartmental memo. 10 Nov 1998.

Table 51. *Abundance (number of trout captured per mile) of wild brown trout in two McKenzie Creek treatment zones before (pre) and after (post) habitat development.*

Treatment Zone	Population Characteristic	Pre-dev. Avg.	Post-dev. Avg.	Percent Change
1	Number of trout fingerlings per mile	145	104	-28
	Number of trout per mile ≥5 inches	161	285	77
	Total number of trout per mile	306	389	27
2	Number of trout fingerlings per mile	65	111	71
	Number of trout per mile ≥5 inches	248	357	44
	Total number of trout per mile	313	468	50



MECAN RIVER

Waushara County
Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 31.0 miles including 16.2 miles of trout water
Average Width: 22 ft
pH: 7.8
Total Alkalinity: 165 ppm
Base Flow Stream Discharge: 22 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
There were bank (boom) covers, wing deflectors, and boulder retards added to the river.

STUDY PERIOD AND DESIGN
There was one 0.8 mile treatment zone with a 0.9 mile reference zone. The pre-development trout population surveys were made July-August 1964 with habitat development being completed in 1965. The post-development population surveys were made July 1967.

A small population of wild rainbow trout is present in the river. However, only pre- and post-comparisons of the brown trout population are addressed in the source document. The two general age classes, young-of-the-year (age 0's) and adults (age I+), are compared and no size classes (e.g., inch groups) are indicated.

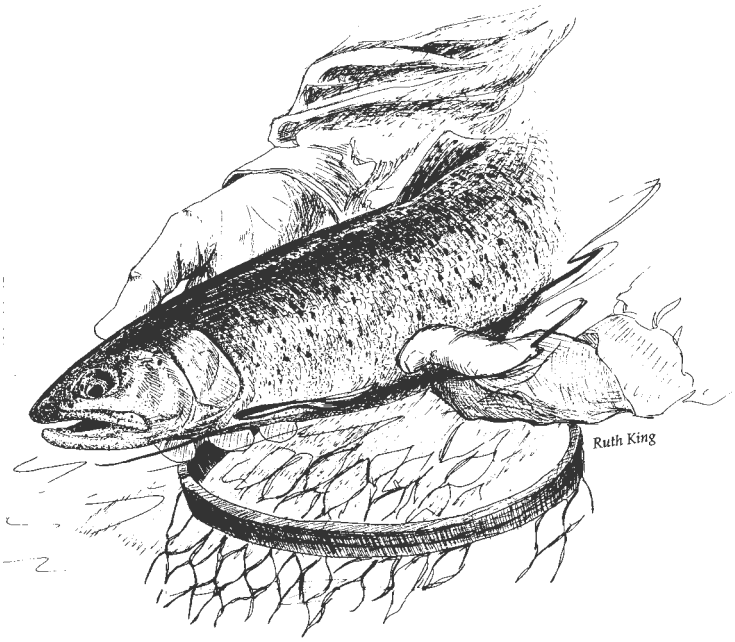
PROJECT COST
None Provided.

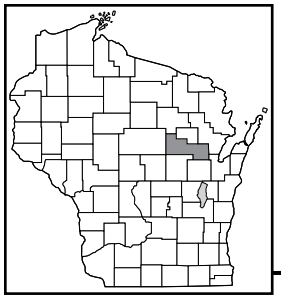
PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Mike Primising.

SUMMARY OF FINDINGS
In the treatment zone, post-development abundance of age 0 and age I+ brown trout increased 73% and 49%, respectively. In the reference zone, post-development abundance of age 0 and age I+ brown trout increased 9% and 11%, respectively. The net increases in age 0 and age I+ brown trout as a result of habitat development were 64% and 38%, respectively.

The source document does not provide actual abundance of brown trout in either study zone. However, total abundance of wild brown trout in a 3.9 mile reach of the Mecan River (which included both the treatment zone and reference zone) increased 56% following habitat development.

SOURCE DOCUMENT
M. Primising, Wisconsin Department of Natural Resources, to Mecan River Water Files, intradepartmental memo. 27 Oct 1967.





MIDDLE BRANCH EMBARRASS RIVER

Shawano County
Wild Brook Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 38.2 miles including 38.2 miles of trout water
Average Width: 42 ft
pH: 7.5
Total Alkalinity: 130 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were bank covers, current deflectors, half-logs, and riprap added to the river.

STUDY PERIOD AND DESIGN
There was one 0.31 mile treatment zone with no reference zone. The age I+ brook trout were surveyed in July 1978. The habitat development was done in the lower half of the treatment zone in 1979 and in the upper half of the treatment zone in 1981. A post-development survey of brook trout was done August 1985. These 2 surveys are compared in Hunt (1988). However, when new trout fishing regulations were implemented in 1990 (a daily bag limit of 5 trout; minimum size limit 7 inches) a second post-development population survey was done in 1994.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Ross Langhurst.

SUMMARY OF FINDINGS
The results of the initial post-development survey done in 1985 was not as good as the results of the final post-development survey done in 1994. When averaging the results for both years, the abundance of brook trout in the treatment zone increased 12% and legal-size brook trout (≥7 inches) increased 71% (Table 52). Qualitative observations in the source document suggest increased angler use in the treatment zone soon after habitat development. Today, fishing pressure is more typical of other streams in the vicinity.

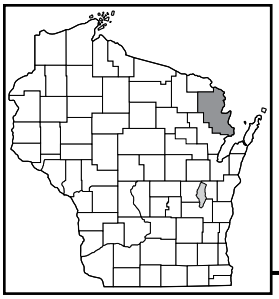
SOURCE DOCUMENTS
R.W Langhurst, Wisconsin Department of Natural Resources, to T.L. Thuemler, personal communication. No Date.

R.W Langhurst, Wisconsin Department of Natural Resources, to E. Avery, personal communication. 3 Jan 2001.

Hunt, R.L. 1988. A compendium of 45 trout stream habitat development evaluations in Wisconsin during 1953-1985. Wisconsin Department of Natural Resources *Technical Bulletin* 162:1-80.

Table 52. *Abundance (number of trout per mile) of wild brook trout in the Middle Branch Embarrass River before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Value	1985 Post-dev. Value	1994 Post-dev. Value	1985 and 1994 Post-dev.Average	Percent Change
Total number of trout per mile	848	674	1,248	947	12
Number of trout per mile ≥7 inches	110	65	310	188	71



MIDDLE INLET CREEK (UPPER)

Marinette County
Wild Brook Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 13.6 miles including 13.6 miles of trout water
Average Width: 13 ft
pH: 7.1
Total Alkalinity: 121 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were 9 bank cover/current deflectors, 23 digger logs, 1 inverted tree stump, 40 boulders, and 70 ft of riprap added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.52 mile treatment zone with no reference zone. The population surveys of age I+ brook trout were completed each June from 1986-93. The habitat development was completed during summer 1987.

Unfortunately, in the source document there was no trout population data providing pre- and post-development abundance comparisons.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Russ Heizer and Cliff Sebero.

SUMMARY OF FINDINGS
There was a positive response in the trout population to habitat development. The total abundance of brook trout increased 8% and abundance of legal-size trout (≥7 inches) increased 240%. Trout biomass increased 58% and may have been in response to the increase in abundance of larger trout (Table 53).

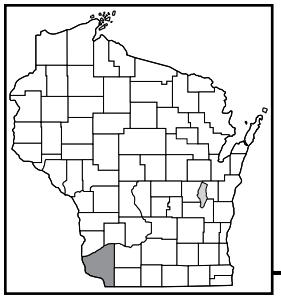
SOURCE DOCUMENTS
R. Heizer, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. No Date.

C. Sebero, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. No Date.

Table 53. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout in the Middle Inlet Creek treatment zone before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	1,320	1,425	8
Number of trout per mile ≥7 inches	143	486	240
Pounds of trout per mile	123[a]	194	58

[a] Biomass value for 1986 only



MILLVILLE CREEK

Grant County
Wild and Domestic Brown Trout
Category 4 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
There were 1,000-2,000 fingerling brown trout added to the creek in the fall.

STREAM DESCRIPTION
Total Length: 5.5 miles including 5.5 miles of trout water
Average Width: 15 ft
pH: 8.1
Total Alkalinity: 220 ppm
Base Flow Stream Discharge: 8.4 cfs
Gradient: 33 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There was riprap added to the creek.

STUDY PERIOD AND DESIGN
A 4.0 mile reach of Millville Creek was riprapped from July through mid-September 1990. A 0.9 mile segment at the upper end of the creek and one 1.1 mile segment at the downstream end of the creek created a 2.0 mile treatment zone. There was no reference zone. The trout abundance in the treatment zone was determined in August-September 1988, 1989, 1992, and 1993. Physical measurements of the stream were made in May 1990 and 1992.

PROJECT COST
The approximate cost of this project was $26,800 per mile riprapped including labor and materials.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Ed Avery.

SUMMARY OF FINDINGS
The post-development physical characteristics of the stream were measured when the stream discharge was 1.9 times greater than when pre-development stream characteristics were measured. Nevertheless, mean stream width remained unchanged while the mean stream depth increased significantly (Table 54). The most striking change was that the number of pools ≥3 ft deep increased 84%. Overhead bank cover, defined as having a minimum of 0.5 ft overhang with water depth of at least 1.0 ft, was scarce before development and declined after development as high water washed away some fallen box elder trees present in the stream. However, little change in the incidence of gravel substrates occurred.

The post-development abundance and biomass of brown trout increased 57% and 108%, respectively (Table 55). The abundance of non-stocked age 0 trout increased 74% and legal-size brown trout (≥12 inches) increased 140%. The small empirical increases in abundance and biomass of brown trout 3 years after riprapping alone did not justify habitat expenditures. However, riprap is used primarily for erosion control and secondarily for trout habitat development.

SOURCE DOCUMENT
Avery, E.L. 1995. Effects of streambank riprapping on physical features and brown trout standing stocks in Millville Creek. Wisconsin Department of Natural Resources. *Research Report* 167:1-80

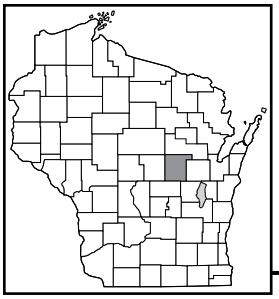
Table 55. *Abundance (number of trout per mile) and biomass (pounds of trout per acre) of wild and domestic brown trout in Mlllville Creek before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Average	Post-dev. Average	Percent Change
Total number of trout per mile	65	102	57
Number of age 0 trout per mile	27	47	74
Number of trout per mile ≥12 inches	15	36	140
Pounds of trout per acre	13	27	108

Table 54. *Physical characteristics of the Millville Creek upper treatment zone (TZ 1) and lower treatment zone (TZ 2) before and after streambank riprapping. For both treatment zones the mean width, mean depth, and amount of gravel substrates, were statistically tested for significance using a t-test.*

	TZ 1			TZ 2		
Characteristic	**1990**	**1992**	**Change**	**1990**	**1992**	**Change**
Stream discharge (cubic feet per second)	4	8.1	4.1	6.9	12.6	5.7
Mean width (feet)	14.6	14.3	-0.3	19.4	19.5	0.1
Mean depth (feet)	0.8	0.9	0.1[a]	0.9	1.2	0.3[a]
Thalweg ≥3 feet	225	260	35	493	874	381
Deepest pools (feet)	4.3	5.5	1.2	5.3	6	0.7
Number of pools ≥3 feet	14	22	8	29	57	28
Percentage of transects with gravel	63	72	9	71	74	3
Percentage of sites within transects with gravel	26	28	2	34	27	-7[a]
Overhead bank cover (feet)	20	2.5	-17.5	127	64	-63

[a] $p < 0.001$



MURRAY CREEK

Waupaca County
Wild Brown Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 1.8 miles including 1.8 miles of trout water
Average Width: 8 ft
pH: 7.9
Total Alkalinity: 165 ppm
Base Flow Stream Discharge: 3.5 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
There were bank cover/current deflectors, riprap, mid-channel logs, digger logs, and temporary sediment traps added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.68 mile treatment zone with an adjacent downstream 0.25 mile reference zone. The pre-development trout population survey was completed in May 1998. The habitat development was done in summer 1998 and the post-development population survey was done in May 2001. Although a few wild brook trout are present in the stream, only wild brown trout data are discussed here.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Al Niebur, Ed Avery, and Chad Cason.

SUMMARY OF FINDINGS
There was a poor response of the trout population to habitat development. The post-development abundance of wild brown trout decreased in both the reference zone and treatment zone and declines were proportionately greater in the treatment zone (Table 56). Following habitat development, total trout abundance decreased 71% in the treatment zone and 59% in the reference zone. The abundance of legal-size brown trout (≥7 inches) also decreased in both study zones following habitat development; declines were once again proportionately greater in the treatment zone. The post-development abundance of legal-size trout (≥7 inches) decreased 76% in the treatment zone and 58% in the reference zone.

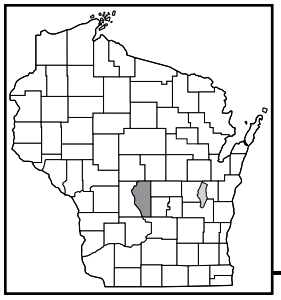
In May 2001, sand blanketed the stream bed and gravel substrates appeared less evident than ever before. This may have been due to logging of a private wood lot 0.4 miles above the treatment zone in the winter of 2000-01. Increased angler harvest in the now easily accessible treatment zone and reference zone may be partially responsible for the decline in the brown trout population.

SOURCE DOCUMENTS
A. Niebur, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. 6 Feb 2001.

E. Avery, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. 4 May 2001.

Table 56. *Abundance (number of trout per mile) of wild brown trout in the Murray Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Population Characteristic	Study Zone	Pre-dev. Value	Post-dev. Value	Percent Change
Total number of trout per mile	TZ	1,313	387	-71
	RZ	1,413	573	-59
Number of trout per mile ≥7 inches	TZ	252	60	-76
	RZ	154	65	-58



NEENAH CREEK

Adams County
Wild Brown Trout
Category 5 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 6.0 miles including 6.0 miles of trout water
Average Width: 8.5 ft
pH: 7.4
Total Alkalinity: 160 ppm
Base Flow Stream Discharge: 12.7 cfs
Gradient: 12.0 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were boom covers, wing deflectors, and brush bundles added to the creek along with selective streambank debrushing.

STUDY PERIOD AND DESIGN
There was one 0.45 mile treatment zone with no reference zone. In the treatment zone, the pre-development trout population surveys were done in July 1989, 1991, and 1992. The habitat development occurred during the summer 1993 and post-development trout surveys were done in July-August 1995, 1996, 1997, and 1998. The trout angling regulations for this creek were changed beginning in 1996. Therefore, only the 1995 post-development survey data is compared to the average 3 year pre-development survey data. The trout angling regulations that have been effect since 1990 include a daily bag limit of 5 trout with a size limit under 10 inches or a daily bag limit of 4 trout under 10 inches and 1 over 15 inches.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Scot Ironside and David Paynter.

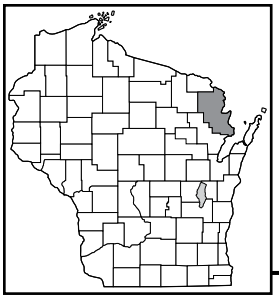
SUMMARY OF FINDINGS
All three wild brown trout population characteristics declined following habitat development (Table 57). The post-development abundance for all sizes of wild brown trout decreased 10%, abundance of trout ≥7 inches decreased 1%, and abundance of trout ≥10 inches decreased 20%.

Although no formal creel surveys were conducted, the source document states that fishing pressure increased following habitat development.

SOURCE DOCUMENT
D. Paynter, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 1 Mar 2000.

Table 57. *Abundance (number of trout per mile) of wild, age I+ brown trout trout in the Neenah Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Average	Post-dev. Value	Percent Change
Total number of trout per mile	559	503	-10
Number of trout per mile ≥7 inches	379	375	-1
Number of trout per mile ≥10 inches	107	86	-20



NORTH BRANCH BEAVER CREEK

Marinette County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 8.7 miles including 8.7 miles of trout water
Average Width: 7 ft
pH: 7.0
Total Alkalinity: 159 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were 10 bank cover/current deflectors added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.23 mile treatment zone with no reference zone. The pre-development population survey of age I+ trout was completed in June 1984. The habitat development began in 1985 and was completed in September 1986 with post-development population surveys of age I+ trout being conducted in June 1990-92.

Raw data providing trout population numbers comparing pre-development and post-development surveys in the treatment zone is not available from the source document. However, a comparison between the pre-development population of age I+ trout and the average 3 year post-development population of age I+ trout was made.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Russ Heizer and Cliff Sebero.

SUMMARY OF FINDINGS
Following habitat development, age I+ brook trout showed an 18% decrease and age I+ brown trout declined by 3%. When combining the 2 species there was a 9% decrease in population abundance after habitat development (Table 58).

Although abundance declined for all sizes of trout combined, legal-size brook trout (≥8 inches) showed a post-development increase of 305% and similar size brown trout increased 134%. Combined, there was a 164% increase in trout ≥8 inches after habitat development (Table 58).

Similarly, legal-size brown trout (≥12 inches) increased 490% and brook trout ≥12 inches increased 1,300% following habitat development. Combined, there was a 550% increase in trout ≥12 inches after habitat development (Table 58).

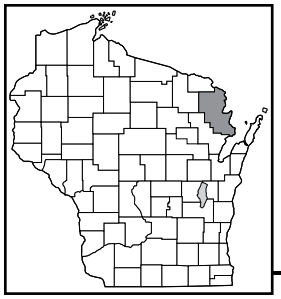
Standing stocks of trout typically increase following habitat development in response to the increase in abundance of larger fish. In this case, the post-development biomass of brook trout increased 65% and biomass of brown trout increased 112%. For both species combined, biomass showed a 100%increase (Table 58).

SOURCE DOCUMENTS
R. Heizer, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. No Date.

C. Sebero, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. No Date.

Table 58. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of age I+ trout in the North Branch Beaver Creek treatment zone (TZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	Brook	202	166	-18
	Brown	306	296	-3
	Combined	508	462	-9
Number of trout per mile ≥8 inches	Brook	22	89	305
	Brown	101	236	134
	Combined	123	325	164
Number of trout per mile ≥12 inches	Brook	0	13	1300
	Brown	22	130	491
	Combined	22	143	550
Pounds of trout per mile	Brook	34	56	65
	Brown	96	204	112
	Combined	130	260	100



NORTH BRANCH PEMEBONWON RIVER (Pemonee River)

Marinette County
Wild and Domestic Brook Trout
Category 2 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
This river receives an annual spring release of 3,825 age I brook trout before and during the first month of the regular trout fishing season.

STREAM DESCRIPTION
Total Length: 22.4 miles including 22.4 miles of trout water
Average Width: 28 ft
pH: 7.5
Total Alkalinity: 108 ppm
Base Flow Stream Discharge: 10-12 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
Beaver dams were removed from this river and free-flowing conditions were regularly maintained.

STUDY PERIOD AND DESIGN
In 1982, spring and fall trout population surveys were conducted in 7 different stations over 2.7 miles of a 9.8 mile treatment zone and in 12 different stations over 1.1 miles on 17.9 miles of seven tributaries entering the treatment zone. A creel survey was conducted throughout the 1982 trout fishing season within the treatment zone and at access points on the tributaries to characterize the sport fishery. During the winter 1982-83, Wisconsin DNR blasting crews removed 219 beaver dams from the treatment zone and its tributaries. An additional 327 beaver dams were removed from the treatment zone from 1983-86, bringing the total number of dams removed to 546. The treatment zone has been maintained free of beaver dams since 1986. Spring and fall trout population surveys were repeated in the treatment zone and the tributaries in 1984, 1986, and 2000. Additional creel surveys were also conducted during these years to determine changes (if any)in the sport fishery. Stocking quotas remained the same throughout the study period and stocked trout were finclipped to facilitate identification from wild trout.

PROJECT COST
The cost of removing beaver dams range from $75 to $150 per mile. Costs of trapping beaver vary depending on the involvement of public trapping.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Ed Avery, Russ Heizer, and Kent Niermeyer.

SUMMARY OF FINDINGS
Wild brook trout populations and the sport fishery have shown dramatic improvements in the Pemonee River treatment zone as a result of removing all beaver dams and maintaining a free-flowing treatment zone.

In the spring of 1982, before removal of the beaver dams, wild brook trout were found in only 4 of 7 tributaries within the treatment zone and in only 4 of 12 stations sampled (Table 59). In the spring of 2000, seventeen years after removal of beaver dams, wild brook trout were present in all 7 tributaries and in all 12 sampling stations. In 2000, brook trout abundance averaged almost 6 times the average abundance before habitat development.

By spring 2000, post-development abundance of all sizes of wild brook trout in the main river increased 73% and legal-size trout (≥7 inches) increased 311% (Table 60). The post-development abundance of all sizes of wild brook trout in fall 2000 increased 24% with legal-size trout accounting for all of the increase (Table 61).

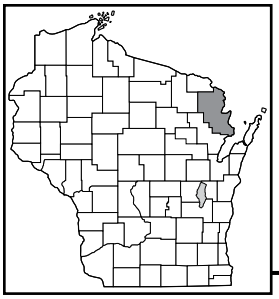
When looking at the creel surveys, the post-development fishing pressure increased 13% compared to pre-development pressure but angler harvest of domestic and wild brook trout increased 33% (Table 62). Domestic brook trout harvest before and after habitat development was essentially the same but harvest of wild brook trout increased 68% and was responsible for 96% of the total increase in harvest of domestic and wild trout. The average size of wild brook trout in the creel survey increased from 7.6 inches before habitat development to 8.9 inches in 2000.

Increased growth rates of brook trout were documented following habitat development and resulted from significant reductions in water temperatures and concurrent increases in the incidence of gravel substrates and aquatic food resources (Avery 2002).

SOURCE DOCUMENTS
Avery, E.L. 1992. Effects of removing beaver dams upon a northern Wisconsin brook trout stream. Wisconsin Department of Natural Resources. Final D-J Report Project No. F-83R, Study No. 406. Madison, WI. 185 pp.

Avery, E.L. 2002. Fish community and habitat responses in a northern Wisconsin brook trout stream 18 years after beaver dam removal. Wisconsin Department of Natural Resources. Final Dingell-Johnson Report Study SSMQ. 54pp.

continued on page 62



NORTH BRANCH PEMEBONWON RIVER (Pempnee River) (continued)

Marinette County
Wild and Domestic Brook Trout
Category 2 Trout Fishing Regulations
Class II Trout Stream

Table 59. *Abundance (number of trout per mile) of wild brook trout in seven tributaries within the North Branch Pemebonwon River treatment zone (TZ) before (pre) and after (post) removal of beaver dams in the spring.*

Tributary Name	Total Length (miles)	Station	Length (feet)	Pre-dev. Value	1986 Post-dev. Value	2000 Post-dev. Value
Ernst Creek	2.2	a	200	0	132	158
		b	200	0	26	132
Lost Creek	1.4	c	600	150	326	643
C & B Creek	2.4	d	300	0	18	563
		e	600	176	88	484
East Cataline Creek	1.7	f	200	185	79	449
Brown Spur Creek	6.1	g	900	0	35	185
		h	900	411	241	1,267
No Name Creek	1.2	I	200	0	158	185
		j	600	0	0	678
Genrick Creek	2.9	k	600	0	9	9
		l	600	0	70	694
Average	2.6		492	77	99	454

Table 60. *Abundance (number of trout per mile) of wild brook trout in the North Branch Pemebonwon River treatment zone before and after removal of beaver dams in the spring.*

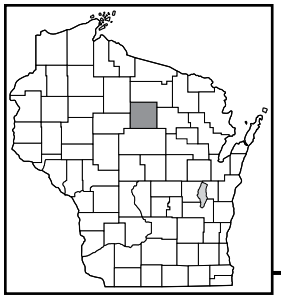
	Year				
Population Characteristic	**1982**	**1984**	**1986**	**2000**	**Percent Change**
Number of trout per mile <7 inches	343	541	332	449	31
Number of trout per mile ≥7 inches	61	42	19	251	311
Total	404	583	351	700	73

Table 61. *Abundance (number of trout per mile) of wild brook trout in the North Branch Pemebonwon River treatment zone before and after removal of beaver dams in the fall.*

	Year				
Population Characteristic	**1982**	**1984**	**1986**	**2000**	**Percent Change**
Number of trout per mile <7 inches	1,163	787	937	1,159	0
Number of trout per mile ≥7 inches	252	118	141	602	139
Total	1,415	905	1,078	1,761	24

Table 62. *Estimated fishing pressure (number of hours fished per acre) and brook trout harvest (number of trout per mile) from the North Branch Pemebonwon River treatment zone before (pre) and after (post) removal of beaver dams.*

Attribute	Pre-development Value	Post-development Value	Percent Change
Fishing pressure	90	102	13
Brook trout harvest			
Wild	104	175	68
Domestic	122	125	2
Total	226	300	33



NORTH BRANCH PRAIRIE RIVER

Lincoln County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 9.2 miles including 9.2 miles of trout water
Average Width: 30 ft
pH: 6.7
Total Alkalinity: 95 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
Approximately 1,320 ft of the 1,624 ft treatment zone was narrowed, deepened, and meandered using a hydraulic excavator. In addition, 6 cross log structures, 102 3-5 ft boulders, 2 brush bundles, and half-logs were installed in the river.

STUDY PERIOD AND DESIGN
There was one 0.31 mile treatment zone with no reference zone. The pre-development single-run electrofishing surveys were done in June 1978 and 1984 and May 1994. The habitat development occurred in the summer 1994 and 1995. A single-run post-development survey of the trout population was done in June 1999.

PROJECT COST
The cost of this project was approximately $5.82 per ft of habitat restored (including employee salaries).

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were David Seibel, Peter Segerson, and Max Johnson.

SUMMARY OF FINDINGS
Catch-per-unit-effort (CPUE) for all sizes of trout and legal-size trout increased following habitat development (Table 63). CPUE for all sizes of brook trout increased 100% and CPUE for all sizes of brown trout increased 405% (Table 63).

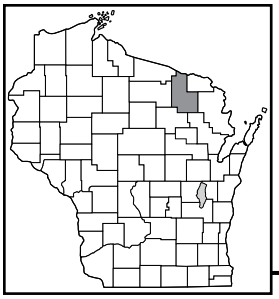
The CPUE of legal-size brook trout (≥8 inches) increased 54% while CPUE of legal-size brown trout (≥12 inches) increased 500%. The combined CPUE for all trout ≥8 inches and all trout ≥12 inches increased 100% (Table 63).

SOURCE DOCUMENTS
P. Segerson, Wisconsin Department of Natural Resources, to M. Zmuda, intradepartmental memo. 15 Dec 1993.

P. Segerson, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files (Final lake and stream habitat improvement report). 15 Feb 1995.

Table 63. *Number of wild brook trout and wild brown trout captured (CPUE) in the North Branch Prairie River treatment zone before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Pre-dev. Average	Post-dev. Value	Percent Change
Total number of trout per mile	Brook	325	650	100
	Brown	20	101	405
	Combined	345	751	118
Number of trout per mile ≥8 inches	Brook	72	111	54
	Brown	6	45	650
	Combined	78	156	100
Number of trout per mile ≥12 inches	Brook	2	0	-200
	Brown	1	6	500
	Combined	3	6	100



NORTH OTTER CREEK

Forest County
Wild Brook Trout
Category 5 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 12.7 miles including 12.7 miles of trout water
Average Width: 16.5 ft
pH: 7.5
Total Alkalinity: 111 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
The creek channel was excavated and single and double whole logs, and boulders were added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.73 mile treatment zone with no reference zone. The pre- and post-development trout population surveys were made in August 1995 and August 1999, respectively. The habitat development occurred in July 1997. The angling regulations in place throughout the study period included a daily bag limit of 5 trout and size of limit of <10 inches, or a daily bag limit and size limit consisting of 4 trout <10 inches and 1 trout >14 inches.

PROJECT COST
None Provided.

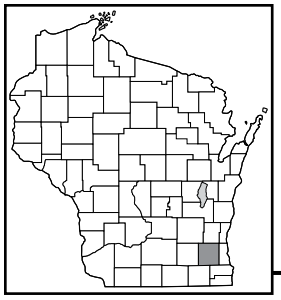
PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Steve AveLallemant, David Brum, and Lloyd Andrews.

SUMMARY OF FINDINGS
The post-development abundance of wild brook trout increased 22% and biomass increased 86% (Table 64). The abundance of brook trout ≥7 inches increased 78% and brook trout ≥9 inches increased 266%.

SOURCE DOCUMENT
D. Brum, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 10 Jan 2000.

Table 64. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild age 0+ brook trout in the North Otter Creek treatment zone before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Value	Post-dev. Value	Percent Change
Total number of trout per mile	3,352	4,082	22
Number of trout per mile ≤6.9 inches	3,131	3,687	18
Number of trout per mile ≥7 inches	222	395	78
Number of trout per mile ≥9 inches	32	117	266
Pounds of trout per mile	112.9	210	86



PARADISE SPRING CREEK (a tributary to the Scuppernong River)

Waukesha County
Wild Brook Trout and Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 0.3 miles including 0.3 miles of trout water
Average Width: 5.0 ft
pH: 8.0
Total Alkalinity: 240 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
The stream bank was debrushed and half-logs were added to the creek.

STUDY PERIOD AND DESIGN
There was one 300 ft treatment zone with no reference zone. The trout population surveys were conducted in June 1987 and 1988. The habitat development was completed with a volunteer labor force from the Southeast Wisconsin Chapter of Trout Unlimited during summer 1987.

PROJECT COST
None Provided.

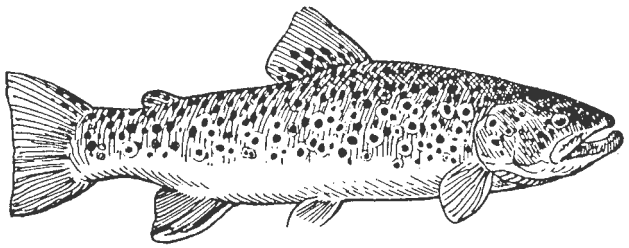
PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Susan Beyler.

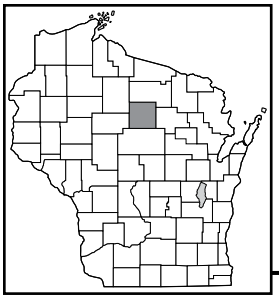
SUMMARY OF FINDINGS
The post-development abundance of both species of trout declined 5% but biomass increased 73% (Table 65). The post-development abundance of brook trout increased 50%, whereas abundance of brown trout declined 29%. Similarly, the post-development biomass of brook trout increased 317%, whereas biomass of brown trout only increased 41%.

SOURCE DOCUMENT
S. Beyler and R. Schumacher, Wisconsin Department of Natural Resources, to J. McNelly, intradepartmental memo. 27 Oct 1988.

Table 65. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and wild brown trout in the Paradise Spring Creek treatment zone before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Pre-dev. Value	Post-dev. Value	Percent Change
Brook	Total number of trout per mile	211	317	50
	Pounds of trout per mile	18	75	317
Brown	Total number of trout per mile	493	352	-29
	Pounds of trout per mile	139	196	41
Combined	Total number of trout per mile	704	669	-5
	Pounds of trout per mile	157	271	73





PRAIRIE RIVER (Below R & H Road)

Lincoln County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 30.9 miles including 30.9 miles of trout water
Average Width: 64 ft
pH: 6.8
Total Alkalinity: 77 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were skyhook bank covers, current deflectors, and boulder retards added to the river.

STUDY PERIOD AND DESIGN
There was one 0.20 mile treatment zone with an adjacent upstream 0.10 mile reference zone. The pre-development trout survey for both study zones was done in June 1985. The habitat development followed in July and August 1985. The post-development population survey in both study zones was done in June 1988 and July 1995. Note that only trout ≥6 inches are reported since this was the minimum size limit prior to 1990. After 1990, Category 4 trout fishing regulations were implemented establishing a minimum size limit of ≥8 inches for brook trout and ≥12 inches for brown trout. These size limits also include a daily bag limit of 3 fish.

PROJECT COST
None Provided.

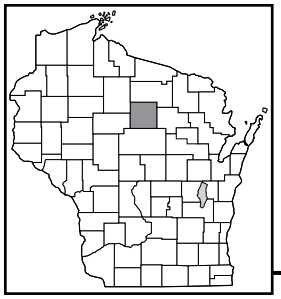
PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Alan Hauber and David Seibel.

SUMMARY OF FINDINGS
Following habitat development, all size groups for both trout species showed population gains in the treatment zone with brown trout exhibiting the greatest population increase (Table 66).

Abundance of brown trout ≥8 inches increased 434% in the treatment zone but decreased 23% in the reference zone. Abundance for similar size brook trout increased 297% in the treatment zone and also increased 93% in the reference zone (Table 66). The post-development abundance of brown trout ≥12 inches increased 1,365% in the treatment zone but decreased 22% in the reference zone. No brook trout ≥12 were present before habitat development and twice the number present in the treatment zone were present in the reference zone after habitat development.

The post-development biomass for both trout species combined increased 247% in the treatment zone but declined 55% in the reference zone. The biomass of brown trout increased 456% in the treatment zone and was responsible for most of the combined biomass gain. Brook trout biomass increased 17% in the treatment zone. The biomass for both species declined in the reference zone after habitat development (Table 66).

SOURCE DOCUMENT
D. Seibel, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 1 Apr 2000.



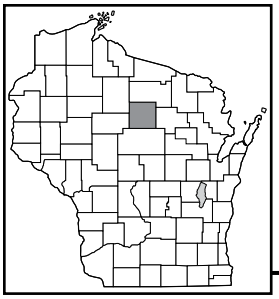
PRAIRIE RIVER (Below R & H Road) continued

Lincoln County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

Table 66. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and wild brown trout in the Prairie River treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Study Zone	1985 Pre-dev. Value	1988 Post-dev. Value	1995 Post-dev. Value	1988 and 1995 Post-dev. Average	Percent Change
Brook	Number of trout per mile ≥6 inches	TZ	384	358	708	533	39
		RZ	777	137	746	442	-43
	Number of trout per mile ≥8 inches	TZ	69	178	368	273	297
		RZ	69	0	265	133	93
	Number of trout per mile ≥12 inches	TZ	0	0	5	3	300
		RZ	0	0	11	6	600
	Pounds of trout per mile	TZ	54	63	N/A	63[a]	17
		RZ	118	20	N/A	20[a]	-83
Brown	Number of trout per mile ≥6 inches	TZ	195	624	1,128	876	349
		RZ	288	218	381	300	4
	Number of trout per mile ≥8 inches	TZ	115	426	803	614	434
		RZ	224	123	223	173	-23
	Number of trout per mile ≥12 inches	TZ	20	172	413	293	1,365
		RZ	65	48	54	51	-22
	Pounds of trout per mile	TZ	64	346	N/A	346[a]	456
		RZ	142	96	N/A	96[a]	-32
Combined	Number of trout per mile ≥6 inches	TZ	579	982	1,836	1,409	143
		RZ	1,065	355	1,127	741	-30
	Number of trout per mile ≥8 inches	TZ	184	604	1,127	866	371
		RZ	293	123	488	306	4
	Number of trout per mile ≥12 inches	TZ	20	172	418	295	1,375
		RZ	65	48	65	57	-12
	Pounds of trout per mile	TZ	118	409	N/A	409[a]	247
		RZ	260	116	N/A	116[a]	-55

[a]1988 data. No data recorded in 1995.



PRAIRIE RIVER (Section 35)

Lincoln County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 30.9 miles including 30.9 miles of trout water
Average Width: 64 ft
pH: 6.8
Total Alkalinity: 77 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were skyhook bank covers, current deflectors, and boulder retards added to the river.

STUDY PERIOD AND DESIGN
There was one 0.33 mile treatment zone with one adjacent upstream 0.19 mile reference zone. The pre-development trout survey for both study zones was done June 1982. The habitat development followed in August 1982 and the post-development population survey was done in June 1985. These results are published in Hunt (1988). There were additional post-development population surveys made in July 1987 and in August 1990-99. In 1990, new trout fishing regulations were implemented which established a size limit of ≥8 inches for brook trout and ≥12 inches for brown trout with a daily bag of 3 fish. All population surveys sampled trout ≥4 inches (age I+). However, since is reported in the initial source document, only data for trout ≥6 inches is used for the current comparisons. There was no biomass data reported in the source documents from 1990-99.

PROJECT COST
None Provided.

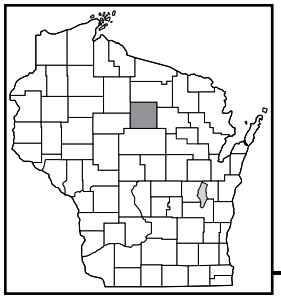
PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Alan Hauber and David Seibel.

SUMMARY OF FINDINGS
Following habitat development, the trout population showed positive changes within the treatment zone. The post-development abundance for both trout species combined increased 24% (Table 67). The average abundance of brook trout ≥6 inches increased 16% after habitat development in the treatment zone, but decreased 7% in the reference zone. For similar size brown trout, the average abundance increased 34% in the treatment zone but decreased 34% in the reference zone. The post-development abundance of brook trout ≥8 inches increased 193% in the treatment zone and also increased 39% in the reference zone. However, similar size brown trout increased only 94% in the treatment zone and declined 69% in the reference zone. All trout sampled ≥12 inches were brown trout. Their post-development abundance in the treatment zone increased 229% but declined 52% in the reference zone. Total biomass for both trout species increased 80% in the treatment zone and may be due to the increase in abundance of larger size trout.

SOURCE DOCUMENTS
A. Hauber, Wisconsin Department of Natural Resources, to M. Johnson, intradepartmental memo. 1 Oct 1985.

D. Seibel, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 1 Apr 2000.

Hunt, R.L. 1988. A compendium of 45 trout stream habitat development evaluations in Wisconsin during 1953-1985. Wisconsin Department of Natural Resources *Technical Bulletin* 162:1-80.



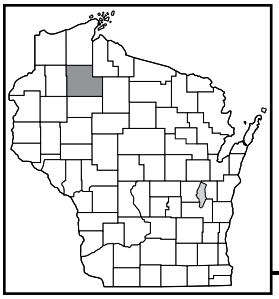
PRAIRIE RIVER (Section 35) continued

Lincoln County
Wild Brook Trout and Wild Brown Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

Table 67. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of wild brook trout and wild brown trout in the Prairie River (section 35) treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Study Zone	Pre-dev. Value	1985 and 1987 Post-dev. Avg.	Percent Change	Post-dev. Average (all years)[a]	Percent Change
Brook	Number of trout per mile ≥6 inches	TZ	960	1,239	29	1,114	16
		RZ	1,302	1,656	27	1,208	-7
	Number of trout per mile ≥8 inches	TZ	81	263	225	237	193
		RZ	166	353	113	231	39
	Pounds of trout per mile	TZ	115	183	59		
		RZ	158	284	48		
Brown	Number of trout per mile ≥6 inches	TZ	712	932	31	957	34
		RZ	767	487	-37	515	-33
	Number of trout per mile ≥8 inches	TZ	215	419	95	417	94
		RZ	234	73	-69	72	-69
	Number of trout per mile ≥12 inches	TZ	41	148	261	135	229
		RZ	21	5	-76	10	-52
	Pounds of trout per mile	TZ	163	318	95		
		RZ	146	70	-52		
Combined	Number of trout per mile ≥6 inches	TZ	1,672	2,171	30	2,071	24
		RZ	2,068	2,143	4	1,724	-17
	Number of trout per mile ≥8 inches	TZ	296	682	130	654	121
		RZ	400	426	7	303	-24
	Number of trout per mile ≥12 inches	TZ	41	148	261	135	229
		RZ	21	5	-76	10	-52
	Pounds of trout per mile	TZ	278	502	80		
		RZ	304	304	0		

[a] Includes data sampled in years after statewide regulation changes.



PRICE CREEK

Sawyer County
Wild Brook Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 9.6 miles including 9.6 miles of trout water
Average Width: 11 ft
pH: 7.2
Total Alkalinity: 43 ppm
Base Flow Stream Discharge: 10.9 cfs
Gradient: 12 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
The streambank was debrushed and brush bundles and half-logs were added to the creek.

STUDY PERIOD AND DESIGN
There was one 1.0 mile treatment zone with no reference zone. The pre-development population survey of age I+ brook trout in the treatment zone was done in July 1981 prior to the initiation of habitat work. The habitat development on 5.1 miles of trout stream was done from 1981-86. The post-development population survey of brook trout in the treatment zone was done in August 1987. Additionally, a partial, random, creel survey was conducted during the first month of the 1995 trout fishing season and a voluntary creel survey was conducted throughout the 1986 trout fishing season. These creel surveys were done in an attempt to estimate fishing pressure and harvest on Price Creek.

PROJECT COST
The total cost to develop trout habitat on 5.1 miles of the creek was approximately $95,379 (including employee salaries).

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Jim Lealos.

SUMMARY OF FINDINGS
The post-development abundance of age I+ brook trout was disappointing. Following habitat development brook trout abundance decreased 5% and abundance of legal-size brook trout (≥6 inches) decreased 45% (Table 68).

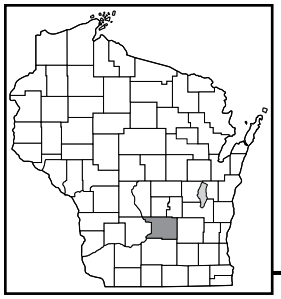
A post-development improvement in spawning habitat and overall cover was observed but not quantified. The 136% increase in abundance of trout ≤6 inches reflected this observed improvement in spawning habitat (Table 68).

The results of the 1995 and 1996 creel surveys indicated very high fishing pressure on the stream that was equal to or better than the most intensely fished streams in the region. The volunteer returns in 1986 indicated a harvest rate of 1.06 fish per hour fished. The estimated season harvest was 246 trout per mile. Price Creek attracted an ever increasing angler clientele throughout the duration of this project and the intense harvest of legal-size trout after the habitat work was completed may have lowered the abundance of fish ≥6 inches.

SOURCE DOCUMENT
J. Lealos, Wisconsin Department of Natural Resources, to E. Avery, Final Report Summary on Project No. FM584. 9 Oct 1991.

Table 68. *Abundance (number of trout per mile) of age I+ wild brook trout in the Price Creek treatment zone before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Value	Post-dev. Value	Percent Change
Total number of trout per mile	1,131	1,074	-5
Number of trout per mile ≤6 inches	250	591	136
Number of trout per mile ≥6 inches	881	483	-45



ROWAN CREEK

Columbia County
Wild Brown Trout
1986 Southern Wisconsin Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 10.6 miles including 10.6 miles of trout water
Average Width: 10 ft
pH: 7.9
Total Alkalinity: 260 ppm
Gradient: 12 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
The streambank was debrushed (mostly large tree removal) and riprap was added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.38 mile treatment zone with no reference zone. Two-thirds of the treatment zone (approximately 1,320 ft) was riprapped on both banks in February 1988. Population surveys of brown trout were made in the treatment zone September 1985-87 and 1990. Beginning in 1986, trout fishing regulations on Rowan Creek changed from a 2 fish daily bag limit with a minimum size limit of 6 inches, to a 2 fish daily bag limit with a minimum size limit of 9 inches during the early trout fishing season. During the regular trout fishing season, regulations on Rowan Creek changed from a daily bag limit of 5 fish with a minimum size limit of 6 inches (for the month of May) and a daily bag limit of 10 fish with a minimum size limit of 6 inches (for the months June-September) to a daily bag limit of 3 fish with a minimum size limit of 9 inches throughout the fishing season. Additionally, in response to the drought in 1988-89, the early trout season (1 January-4 May 1990) was closed in 12 counties (including Columbia County). The impacts of these regulatory changes may have contributed to changes in the trout population following habitat development.

PROJECT COST
The cost of this project was approximately $4.58 per ft of habitat restored plus labor.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Tim Larson.

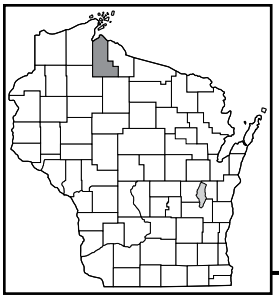
SUMMARY OF FINDINGS
Following habitat development, the total abundance of wild brown trout decreased 48% but abundance of larger size trout increased (Table 69). The post-development abundance of brown trout <6 inches (age 0) decreased 87%. This poor year class strength in 1990 was probably the result of low water levels and sediment accumulation accompanying the drought in 1988-90.

The post-development abundance of intermediate size brown trout (6.0-9.4 inches) decreased 16% but abundance of trout ≥9.5 inches increased 255%. The post-development abundance of brown trout >12 inches increased 250% (Table 69).

SOURCE DOCUMENT
T. Larsen, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 5 Jan 2000.

Table 69. *Abundance (number of trout per mile) of wild brown trout in the Rowan Creek treatment zone before (pre) and after (post) habitat development.*

Population Characteristic	Age Group	Pre-dev. Average	Post-dev. Value	Percent Change
Number of trout per mile <6 inches	0	1,173	154	-87
Number of trout per mile 6.0 to 9.4 inches	I	251	211	-16
Number of trout per mile 9.5 to 11.9 inches	II	82	293	257
Number of trout per mile ≥12 inches	III+	42	147	250
Total number of trout per mile		1,548	805	-48



SPRING BROOK

Ashland County
Wild Brook Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 5.7 miles including 5.7 miles of trout water
Average Width: 9 ft
pH: 7.2
Total Alkalinity: 39 ppm
Gradient: 47 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
The streambank was debrushed and brush bundles, boom covers, wing deflectors, and riprap were added to the brook.

STUDY PERIOD AND DESIGN
There was one 1.19 mile treatment zone with no reference zone. The habitat improvement occurred during a 5 year period from 1979-83. The pre- and post-development trout population surveys were done in June 1978 and June 1986, respectively.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Skip Sommerfeldt and Jeff Roth.

SUMMARY OF FINDINGS
The post-development abundance of wild brook trout ≥4 inches increased 20% but legal-size brook trout (≥6 inches) declined 23% (Table 70). However, in 1986 a large number of brook trout between 5.5-5.9 inches (186 per mile; Sommerfeldt 2000) were sampled. It is presumed that these trout that would grow to legal size by early July. Unfortunately, the pre-development survey was completed in June. If we include these brook trout in the post-development abundance of legal-size trout, it would result in a value of 532 trout per mile resulting in a 19% increase.

The source documents indicate that fishing opportunities increased following habitat development due to improved "fishability" of the stream. Anglers interviewed indicated excellent success and most anglers and tourists were satisfied with the quality of the fishery.

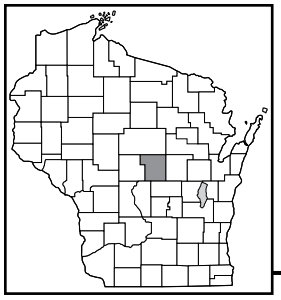
SOURCE DOCUMENTS
J. Roth, Wisconsin Department of Natural Resources, to J.C. Wolters (USFWS), intradepartmental memo. No Date.

S. Sommerfeldt, Wisconsin Department of Natural Resources, to H. Sheldon, intradepartmental memo. 2 Apr 1985.

S. Sommerfeldt, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 12 Jan 2000.

Table 70. *Abundance (number of trout per mile) of wild brook trout ≥4 inches in the Spring Brook treatment zone before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Value	Post-dev. Value	Percent Change
Number of trout per mile <6 inches	133	351	164
Number of trout per mile ≥6 inches	448	346	-23
Total number of trout per mile	581	697	20



TOMORROW RIVER (Upper)

Portage County
Wild Brook Trout and Wild Brown Trout
Category 5 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 12.0 miles including 12.0 miles of trout water
Average Width: 28.8 ft
pH: 8.0
Total Alkalinity: 216 ppm
Base Flow Stream Discharge: 21.0 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
There were boom covers, wing deflectors, brush bundles, and boulder retards added to the river. In addition, selective streambank debrushing was done.

STUDY PERIOD AND DESIGN
There was one 0.39 mile treatment zone with no reference zone. The pre-development trout population survey was done in the treatment zone August 1988. The habitat development occurred in the upper 0.18 mile of the treatment zone during summer 1990 and Habitat development in the lower 0.21 mile of the treatment zone occurred during summer 1991. The post-development trout surveys were done in August 1993 and 1996.

PROJECT COST
None Provided.

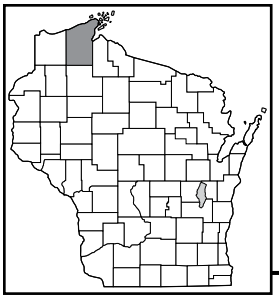
PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Scot Ironside and David Paynter.

SUMMARY OF FINDINGS
Interestingly, there were more brook trout than brown trout prior to habitat development but following habitat development the opposite was true (Table 71). The post-development abundance of age I+ brook trout decreased 1% but age I+ brown trout increased 216%. The abundance of brook trout ≥6 inches, ≥9 inches, and ≥10 inches increased 37%, 64%, and 200%, respectively and the corresponding size groups for brown trout all increased more than 200%. The abundance of both trout species combined increased 52% following habitat development with trout ≥10 inches showing a 231% increase.

SOURCE DOCUMENT
D. Paynter, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 1 Mar 2000.

Table 71. *Abundance (number of trout per mile) of wild, age I+ brook trout and brown trout in the Upper Tomorrow River treatment zone before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Pre-dev. Value	Post-dev. Average	Percent Change
Brook	Total number of trout per mile	608	602	-1
	Number of trout per mile ≥6 inches	323	444	37
	Number of trout per mile ≥9 inches	25	41	64
	Number of trout per mile ≥10 inches	5	15	200
Brown	Total number of trout per mile	199	628	216
	Number of trout per mile ≥6 inches	186	568	205
	Number of trout per mile ≥9 inches	127	387	205
	Number of trout per mile ≥10 inches	101	336	233
Combined	Total number of trout per mile	807	1,230	52
	Number of trout per mile ≥6 inches	509	1,012	99
	Number of trout per mile ≥9 inches	152	428	182
	Number of trout per mile ≥10 inches	106	351	231



TWENTY MILE CREEK

Bayfield County
Wild Brook Trout and Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 9.2 miles including 9.2 miles of trout water
Average Width: 10.0 ft
pH: 7.4
Total Alkalinity: 59 ppm
Base Flow Stream Discharge: 2.7 cfs
Gradient: 45 ft per mile

TYPE OF DEVELOPMENT/ENHANCEMENT
There were bank cover logs, wing deflectors, channel constrictors, cross channel log/bank revetments, tip deflectors, wedge dams, and whole log covers added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.13 mile treatment zone and with one 0.09-mile reference zone adjacent to and downstream of the treatment zone. The habitat structures were installed from July-August 1985 with the trout populations surveys in the study zones done in September 1983-89. The physical characteristics of the study zones were measured in September 1983 and August 1989 (Table 72). Underbank hiding cover was defined as the face length of stream bank providing a minimum of 0.5 ft of overhang with a minimum of 0.5 ft of water beneath it.

This study was part of a larger investigation of habitat improvement structures on high gradient streams involving Camp Creek (1984-89) and Devils Creek (1983-89)(Hunt 1992).

PROJECT COST
The cost of this project was approximately $35,238 per mile of habitat restored, which included supplies, wages, vehicle mileage, and heavy equipment rental.

PRINCIPAL INVESTIGATOR(S)
The principal investigator for this project was Robert Hunt.

SUMMARY OF FINDINGS
Following habitat development in the treatment zone, there was a 1,479% increase in underbank hiding cover for trout (Table 72), even though baseflow stream discharge in August 1989 was 33% less than that measured in September 1983. Conversely, the amount of underbank hiding cover in the reference zone declined 16%. The average width and depth of the creek decreased in both study zones following habitat development. These relationships suggest a positive benefit of habitat development during periods of low stream flow.

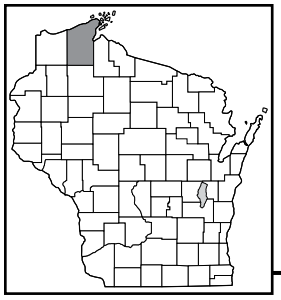
The post-development abundance of age 0+ brook trout decreased 32% in both study zones (Table 73). Similarly, the post-development abundance for all sizes of brown trout also decreased in both study zones. For both species, the reduced recruitment of age 0 trout may be the primary reason for the post-development declines in the total number of trout present in the study zones. However, despite low recruitment after habitat structures were installed, the post-development abundance for both species of legal-size (≥6 inches) trout increased in the treatment zone. When combining both species, there was a 93% increase in abundance of legal-size trout in the treatment zone compared to a 5% decrease in the reference zone.

The biomass of brook trout and brown trout both increased in the treatment zone following habitat development and these gains were paired with biomass declines in the reference zone (Table 73). The increased biomass of legal-sized trout appears to offset the reduction in biomass of age 0 trout due to poor post-development recruitment in the treatment zone.

SOURCE DOCUMENT
Hunt, R.L. 1992. Evaluation of trout habitat improvement structures in three high-gradient streams in Wisconsin. Wisconsin Department of Natural Resources. *Technical Bulletin* 179:1-40

Table 72. *Physical characteristics of the Twenty Mile Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Characteristic	Study Zone	Pre-dev. Value	Post-dev. Value	Percent Change
Average width (feet)	TZ	13.5	8.6	-36
	RZ	13.9	11.9	-14
Average depth (inches)	TZ	5.1	4.1	-20
	RZ	6.7	4	-40
Under bank cover (linear feet)	TZ	17	268.5	1,479
	RZ	35	29.4	-16
Stream baseflow (cfs)	RZ	2.7	5.2	-57

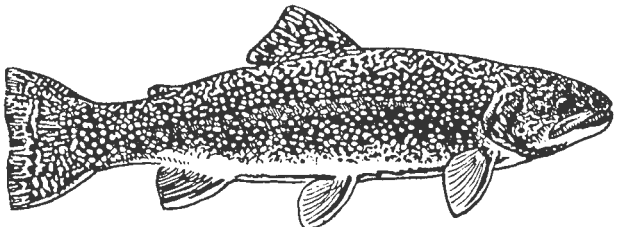


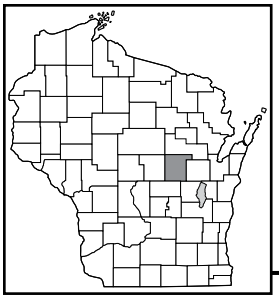
TWENTY MILE CREEK continued

Bayfield County
Wild Brook Trout and Wild Brown Trout
Pre-1990 Trout Fishing Regulations
Class I Trout Stream

Table 73. *Abundance (number of trout per mile) and biomass (pounds of trout per mile) of age 0+ brook trout and wild brown trout in the Twenty Mile Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Study Zone	Pre-development Average	Post-development Average	Percent Change
Brook	Total number of trout per mile	TZ	1,700	1,150	-32
		RZ	1,870	1,280	-32
	Number of trout per mile ≥6 inches	TZ	85	185	118
		RZ	189	189	0
	Pounds of trout per mile	TZ	41	46	12
		RZ	56	47	-16
Brown	Total number of trout per mile	TZ	295	252	-15
		RZ	182	92	-49
	Number of trout per mile ≥6 inches	TZ	52	77	48
		RZ	29	19	-34
	Pounds of trout per mile	TZ	13	17	31
		RZ	8	6	-25
Combined	Total number of trout per mile	TZ	1,995	1,402	-30
		RZ	2,052	1,372	-33
	Number of trout per mile ≥6 inches	TZ	136	262	93
		RZ	218	208	-5
	Pounds of trout per mile	TZ	54	64	19
		RZ	64	52	-19





WAUPACA RIVER

Waupaca County
Wild Brook Trout and Wild and Domestic Brown Trout
Category 4 and 5 Trout Fishing Regulations
Class II Trout Stream

STOCKING PROTOCOL
The stocking protocol for this river includes an annual fall stocking of fingerlings at density of 1,750 per mile.

STREAM DESCRIPTION
Total Length: 24.7 miles including 13.2 miles of trout water
Average Width: 66 ft
pH: 8.5
Total Alkalinity: 180 ppm
Base Flow Stream Discharge: 180 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
There was approximately 720 ft of skyhook bank cover, 1500 ft of current deflectors, 800 ft, of channel braiding/island construction, 200 ft of riprap, 100 half-logs, and numerous bolder retards added to the river.

STUDY PERIOD AND DESIGN
There was one 0.76 mile treatment zone with one 0.61 mile reference zone separated by 3 river miles. The pre-development trout population surveys in both study zones were done in fall 1993 and 1994. Approximately 95% of the habitat development was completed summer 1995 and the remaining 5% was completed summer 1997. The post-development trout population surveys were done in fall 1996-98 and 2000.

PROJECT COST
The cost of this project was approximately $28,000 (not including employee salaries).

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Al Niebur and Ed Avery.

SUMMARY OF FINDINGS
The post-development abundance for all sizes of brown trout combined increased in both study zones. The abundance of brown trout in the treatment zone increased 73% and increased 49% in the reference zone (Table 74).

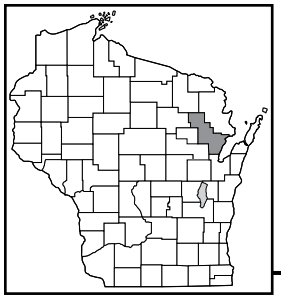
The abundance of brown trout ≥7 inches increased 27% in the treatment zone but decreased 15% in the reference zone. For "quality size" trout (≥12 inches), the post-development abundance in the treatment zone increased 172% but only increased 59% in the reference zone. Following habitat development, remnant, wild brook trout populations declined in both study zones but the proportional decline was less in the treatment zone (Table 74).

SOURCE DOCUMENTS
A. Niebur, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. 6 Feb 2001.

E. Avery, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. 5 Mar 2001.

Table 74. *Abundance (number of trout per mile) of wild and domestic brown trout and wild brook trout in the Waupaca River treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Population Characteristic	Trout Species	Study Zone	Pre-development Average	Post-development Average	Percent Change
Total number of trout per mile	Brown	TZ	825	1,424	73
		RZ	2,662	3,962	49
	Brook	TZ	60	34	-43
		RZ	4	2	-50
Number of trout per mile ≥7 inches	Brown	TZ	384	487	27
		RZ	902	764	-15
	Brook	TZ	10	24	140
		RZ	4	1	-75
Number of trout per mile ≥12 inches	Brown	TZ	39	106	172
		RZ	73	116	59
	Brook	TZ	0	0	0
		RZ	0	0	0



WAUPEE CREEK

Oconto County
Wild and Domestic Brook Trout and Wild Brown Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
The stocking protocol for this creek included an annual spring stocking age 0 brook trout 2.3 miles below the treatment zone.

STREAM DESCRIPTION
Total Length: 12.1 miles including 12.1 miles of trout water
Average Width: 24 ft
pH: 7.0
Total Alkalinity: 92 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There was a sediment trap and gravel spawning riffle added to the creek.

STUDY PERIOD AND DESIGN
There was one 1.2 mile treatment zone with one upstream 0.25 mile reference zone. A sediment trap was excavated in the upper 216 ft of the treatment zone February 1987. No cleaning of the sediment trap was necessary during the study. Additionally, an adjacent 100 ft rock-sill-and-gravel spawning riffle was constructed downstream of the sediment trap in August 1988. The physical characteristics of both study zones were measured 1987 and 1989 (Table 76). The trout population surveys were done in August 1986-91 in both study zones.

This study was part of a larger investigation of sediment traps and artificial gravel riffles to improve trout reproduction involving Hay Creek (1984-90) and Chaffee Creek (1984-91)(Avery 1996).

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Ed Avery, Russ Heizer, and Kent Niermeyer.

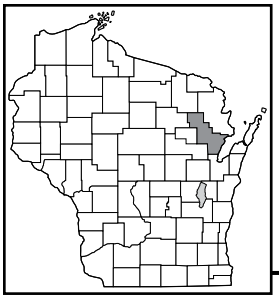
SUMMARY OF FINDINGS
The primary objective of this habitat development was to increase gravel substrates and improve natural reproduction of trout in a predominantly sand-bottomed stream. Unfortunately the post-development response of the trout population was disappointing. The abundance of brook trout in the treatment zone increased 60% but also increased 62% in the reference zone (Table 75). The post-development abundance of brown trout decreased 37% in the treatment zone and 38% in the reference zone. As a result, the combined trout population increased only 7% in the treatment zone and 8% in the reference zone.

The response of natural recruitment to habitat development was disappointing. The post-development abundance of age 0 trout declined in both study zones, although the decline was proportionately less in the treatment zone (Table 75).

There were no dramatic physical changes in Waupee Creek following habitat development. The average width and average depth in both study zones increased but may have been probably a function of the 40% increase in baseflow stream discharge from 1987 to 1989 (Table 76). The occurrence of gravel substrates declined in the reference zone and only increased slightly in the treatment zone with the practical significance of these changes upon natural recruitment was negligible.

SOURCE DOCUMENT
Avery, E.L. 1996. Evaluations of sediment traps and artificial gravel riffles constructed to improve reproduction of trout in three Wisconsin streams. *North American Journal of Fisheries Management* 16:282-293.

continued on page 78



WAUPEE CREEK continued

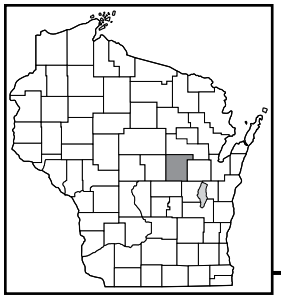
Oconto County
Wild and Domestic Brook Trout and Wild Brown Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

Table 75. *Abundance (number of trout per mile) of domestic brook trout and wild brown trout in the Waupee Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

Trout Species	Population Characteristic	Study Zone	Pre-development Average	Post-development Average	Percent Change
Brook	Total number of trout per mile	TZ	253	406	60
		RZ	204	331	62
	Number of age 0 trout per mile	TZ	87	119	37
		RZ	24	6	-75
	Number of age I+ trout per mile	TZ	166	287	73
		RZ	180	325	81
Brown	Total number of trout per mile	TZ	303	190	-37
		RZ	241	150	-38
	Number of age 0 trout per mile	TZ	134	39	-71
		RZ	56	0	-100
	Number of age I+ trout per mile	TZ	169	151	-11
		RZ	185	150	-19
Combined	Total number of trout per mile	TZ	556	596	7
		RZ	445	481	8
	Number of age 0 trout per mile	TZ	221	158	-29
		RZ	80	6	-93
	Number of age I+ trout per mile	TZ	335	438	31
		RZ	365	475	30

Table 76. *Physical characteristics of the Waupee Creek treatment zone (TZ) and reference zone (RZ) before (pre) and after (post) habitat development.*

	RZ			TZ		
Characteristic	Pre-development Value	Post-development Value	Percent Change	Pre-development Value	Post-development Value	Percent Change
Stream discharge (cubic feet per second)				16.9	23.7	40
Average width (feet)	16.4	17.4	6	19.7	22.3	13
Average depth (feet)	1.4	1.7	21	1.1	1.4	27
Percentage of transects with gravel	40	32	-20	0	12	1,200
Percentage of sites within transects with gravel	8	6	-2	0	1	1



WHITCOMB CREEK

Waupaca County
Wild Brook Trout
Category 2 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 7.3 miles including 7.3 miles of trout water
Average Width: 17 ft
pH: 8.4
Total Alkalinity: 182 ppm
Base Flow Stream Discharge: 7.6 cfs

TYPE OF DEVELOPMENT/ENHANCEMENT
The streambank was debrushed and there were mini-lunker structures, boulder retards, brush mats, riprap, and half-logs added to the creek.

STUDY PERIOD AND DESIGN
There was one 0.47 mile treatment zone with no reference zone. The age I+ trout were surveyed in the treatment zone in August 1996. The habitat development work was completed in summer 1997 and post-development trout surveys were done June 1998 and 1999.

PROJECT COST
None Provided.

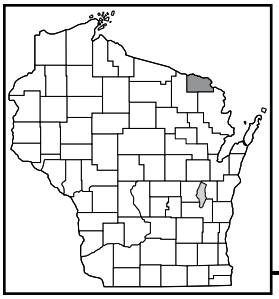
PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Al Niebur and Chad Cason.

SUMMARY OF FINDINGS
The response of the brook trout population to habitat development was disappointing. The total trout abundance declined 7% and legal-size trout (≥7 inches) declined 6% after habitat development (Table 77).

SOURCE DOCUMENT
A. Niebur, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. 6 Feb 2001.

Table 77. *Abundance (number of trout per mile) of age I+ brook trout in the Whitcomb Creek treatment zone before (pre) and after (post) habitat development.*

Population Characteristic	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	553	512	-7
Number of trout per mile ≥7 inches	143	135	-6



WISCONSIN CREEK

Florence County
Wild Brook Trout
Category 4 Trout Fishing Regulations
Class I Trout Stream

STOCKING PROTOCOL
None Provided.

STREAM DESCRIPTION
Total Length: 5.9 miles including 5.9 miles of trout water
Average Width: 9 ft
pH: 7.1
Total Alkalinity: 99 ppm

TYPE OF DEVELOPMENT/ENHANCEMENT
There were 6 bank cover/current deflectors added to the creek; 650 ft of brush bundling and debrushing was also done.

STUDY PERIOD AND DESIGN
There was one 0.23 mile treatment zone with no reference zone. There was a single-run for age I+ trout (≥4 inches) done in August 1985. The habitat development was done August 1987 and double-run electrofishing surveys were done August 1991, 1992, and 1998. Only the average of the first electrofishing runs done in 1991, 1992, and 1998 were compared to the single-run electrofishing run done in 1985.

Since only 1 brown trout was sampled in 1985 the summary below will be restricted to brook trout.

PROJECT COST
None Provided.

PRINCIPAL INVESTIGATOR(S)
The principal investigators for this project were Russ Heizer and Cliff Sebero.

SUMMARY OF FINDINGS
The post-development abundance (CPUE) of age I+ brook trout increased 35% in the treatment zone and CPUE of brook trout ≥7 inches increased 39% (Table 78).

SOURCE DOCUMENTS
R. Heizer, Wisconsin Department of Natural Resources, to P. Cline, intradepartmental memo. 11 Mar 1980.

R. Heizer, Wisconsin Department of Natural Resources, to E. Higgs, intradepartmental memo. 3 Jul 1986.

R. Heizer, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental files. No Date.

C. Sebro, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 9 Dec 1999.

C. Sebro, Wisconsin Department of Natural Resources, to E. Avery, intradepartmental memo. 13 Jun 2001.

Table 78. *Catch per unit effort (CPUE) of age I+ brook trout in the Wisconsin Creek treatment zone before (pre) and after (post) habitat development.*

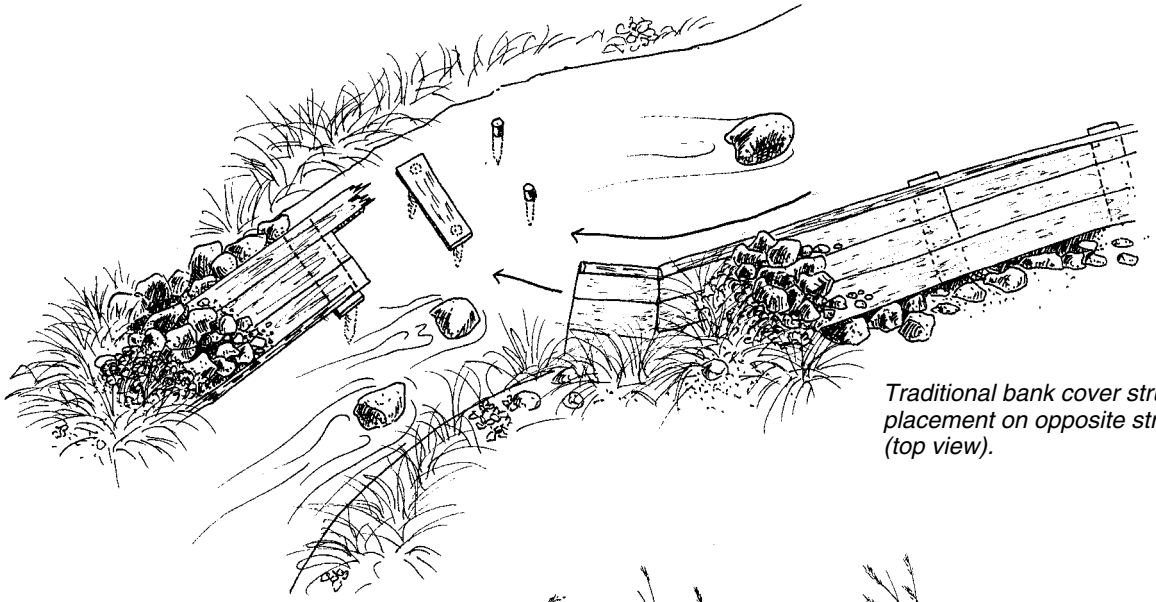
Population Characteristic	Pre-dev. Value	Post-dev. Average	Percent Change
Total number of trout per mile	413	557	35
Number of trout per mile ≥7 inches	110	153	39

Glossary of Habitat Development Techniques

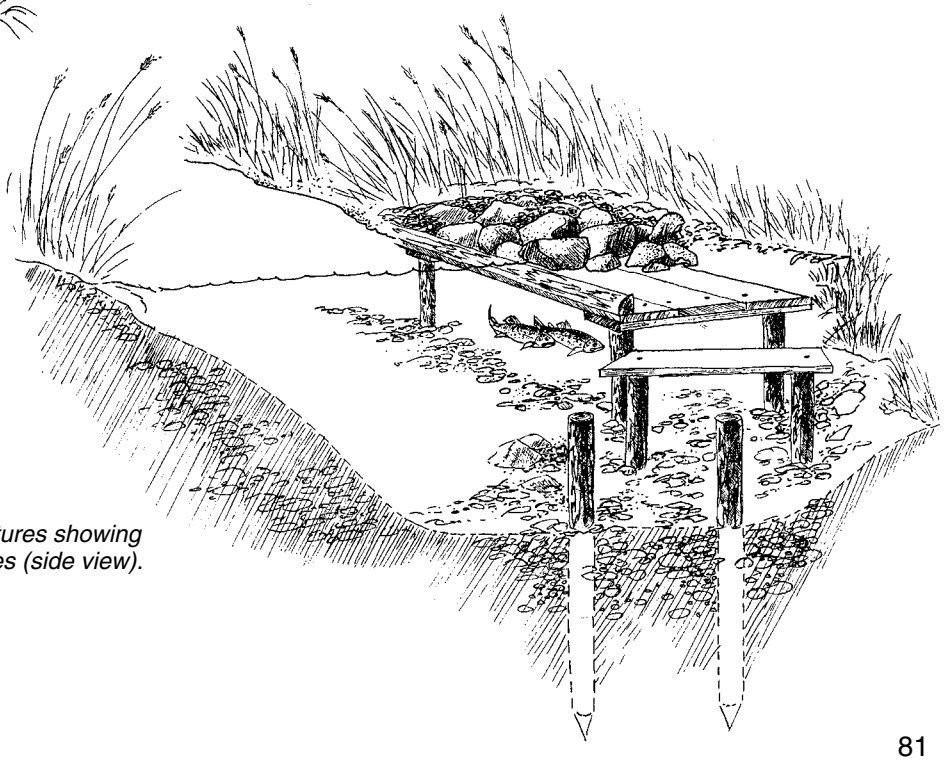
Bank Cover/Current Deflector Structures

In Wisconsin, this dual-purpose structure has evolved during the past 50 years to a place of preeminence among the variety of techniques used to improve trout stream habitats. In addition, several variations in the construction procedures and materials used have surfaced, but the basic design, purpose, and pattern of installation have persisted. No other habitat structure provides as much simultaneous gain in pool area and stable resting cover. The quantity and quality of these two environmental features frequently constitute the most important factors limiting abundance of adult trout in streams degraded by human effects.

Typical construction of Bank Cover/Current Deflector Structures begins by securely embedding pairs of 5 ft. long wooden pilings in the stream bottom. The pilings are "jetted" into sand and gravel substrates using a pressurized jet of water to bore a hole for each piling. "Stringer planks" of green-cut hardwood are then nailed underwater to each pair of pilings. These planks extend at right angles from the natural stream bank. Additional green hardwood planks are then nailed on top of the stringer planks and parallel with the natural stream bank to complete an underwater platform. A width of 3 to 5 feet is common, but may vary depending on the degree



Traditional bank cover structures showing placement on opposite stream banks (top view).



Traditional bank cover structures showing construction stages (side view).

of stream channel narrowing that is desired. A quarter-log lip is attached along the top, outside edge of the structure to prevent building materials from falling into the stream. Next, the platform is covered with stones. Larger stones are placed along the outside edge to provide a solid wall. The stones are covered with dirt and seeded to complete construction of the new stream bank.

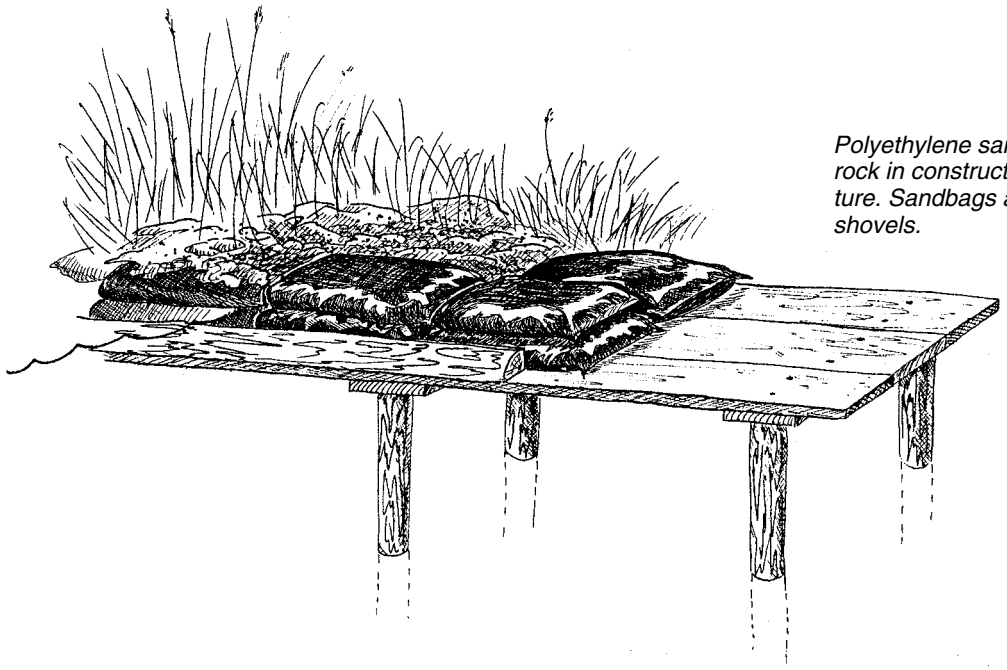
The new stream bank will provide overhanging cover for trout to utilize in combination with adequate water depth. Adequate depth is assured by building the structures sequentially along the contours of the current-bearing banks of the stream. One structure directs the current across channel into another structure in an accentuated meander pattern. The downstream end of one structure slightly overlaps the upstream end of the next structure. Stream flow, confined by the artificially narrowed banks, will scour a pool under most of the length of each structure.

A substitute process using polyethylene sandbags (16 inches $\times$ 29 inches) instead of rock can be used to fill on top of the wooden platforms. This process is used where fieldstone or quarried rock is either not available or difficult to transport to the stream. The sandbags are filled on-site with material shoveled by hand from the stream bed. Sandbags are piled 2 rows deep and 2 rows high on the outside edge of the platform. The bags are then covered with dirt and seeded.

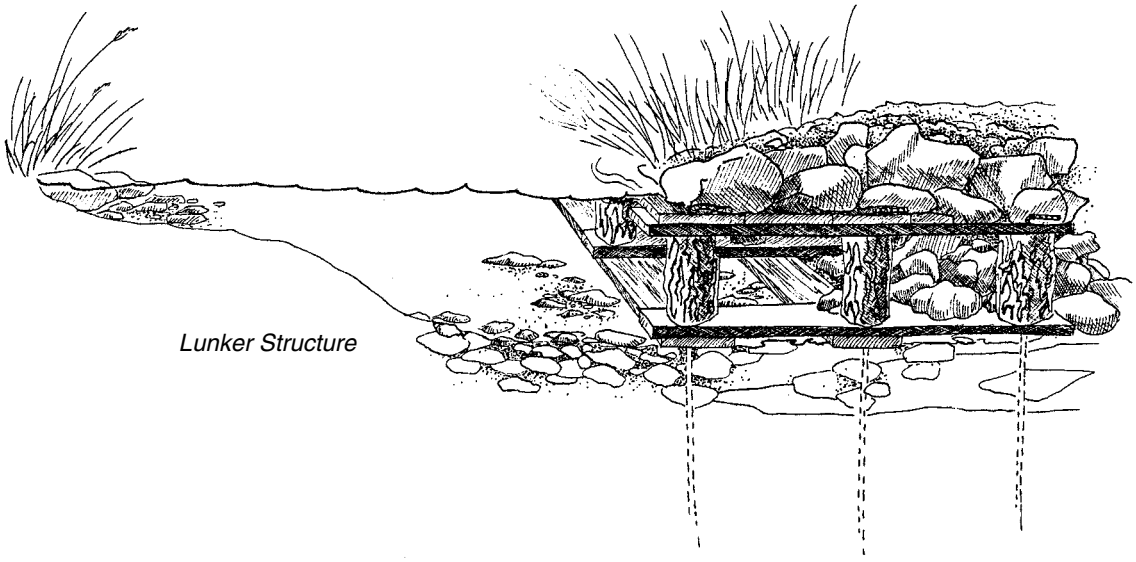
Other Bank Cover/Current Deflector Structures

Several variations in bank cover and current deflector structures have been devised for use in stream bottoms where installing pilings may not be feasible. Steel re-enforcement rods are driven through the corners of prefabricated, sandwich-like platforms ("lunker structures") that rest directly on the stream bottom. These prefabricated platforms are constructed in a standard size and joined together in the stream to form a new, artificial stream bank support system. Additionally, heavy excavation equipment can be used to dig a new channel in the stream bottom. When this technique is used, pre-fabricated platforms ("skyhook covers") are partially cantilevered out over the excavated channel. The excavated material is then used to cover the back half of each platform, providing a weight counterbalance and, when piled high enough, a new stream bank. Structures are finished off with dirt, seed, or sod to simulate a natural grassy bank. Large boulders are commonly placed in the excavated channels to provide middle of the channel resting and feeding areas.

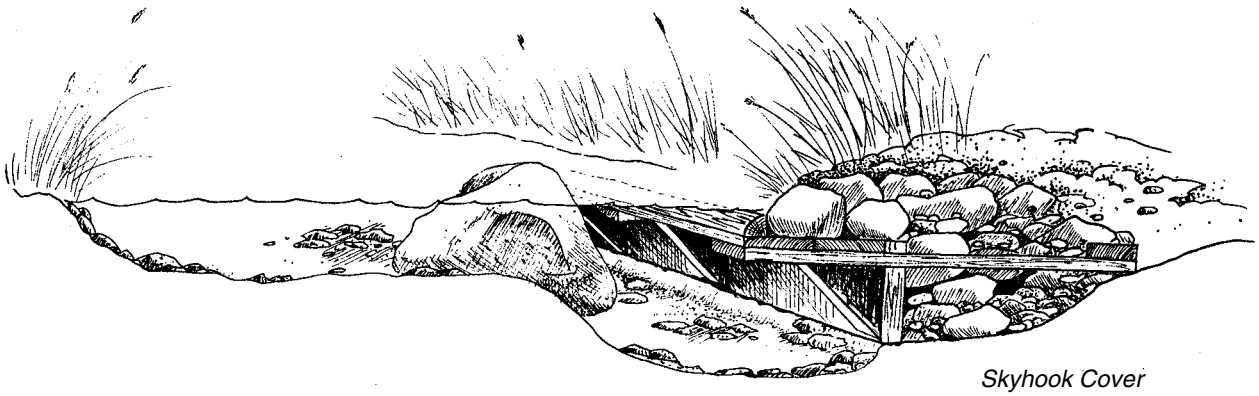
An alternative to the use of platforms on hard-bottom streams is the "bank cover log and current deflector". Steel re-enforcement rods are used to pin partly notched out logs in place along relatively straight stream reaches. A wedge-shaped current deflector constructed of logs and filled with rock is installed on the opposite bank and slightly upstream from the partly notched out logs. These structures can be used without deflectors if stream flow is naturally focused toward them.



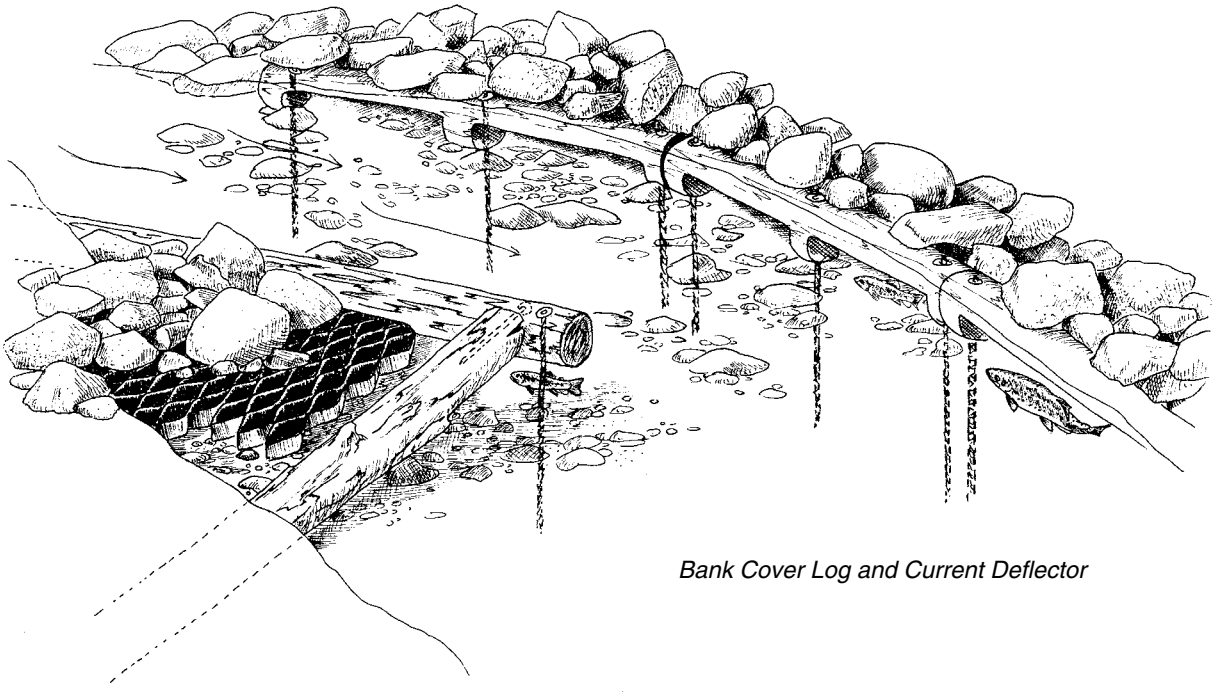
Polyethylene sandbags substituted for rock in construction of bank cover structure. Sandbags are filled on site using shovels.



Lunker Structure



Skyhook Cover



Bank Cover Log and Current Deflector

Beaver Dam Removal

Detrimental effects of beaver dams on trout populations in low to moderate gradient trout streams typical of Wisconsin were recognized in the late 1940's and early 1950's. During the late 1970's and early 1980's, beaver populations burgeoned creating unprecedented densities of >1 beaver dam per mile on many northern Wisconsin streams. During this period, emphasis on beaver trapping and the removal of beaver dams in a "shotgun" approach throughout the state was the trout stream management philosophy. But was able to yield little lasting benefit.

In the mid-1980's, significant improvements in both the environment and brook trout populations were observed when intensive beaver dam removal and continued maintenance of free-flowing conditions was maintained in a northern Wisconsin watershed. In 1986, fishery managers selected specific high-priority watersheds in which to focus beaver dam removal efforts. At that time, beaver dam removal was recognized as a legitimate trout habitat development procedure that could be funded by trout stamp revenue (i.e. since 1977, trout anglers on inland waters of Wisconsin have been required to purchase a trout stamp in addition to their regular fishing license. Revenue from trout stamp sales is reserved exclusively for trout habitat development). Today, beaver dam removal projects focus on specific watersheds located primarily across northern Wisconsin. In 1988, the Wisconsin DNR contracted with the U.S. Department of Agriculture's Animal Plant Health Inspection Service (Animal Damage Control) to maintain selected watersheds as "free-flowing". Aerial flights are flown annually over these watersheds to detect beaver activity and, if found, is followed by ground reconnaissance. Beaver are trapped and dams are consequently destroyed and removed.

Drained beaver pond.

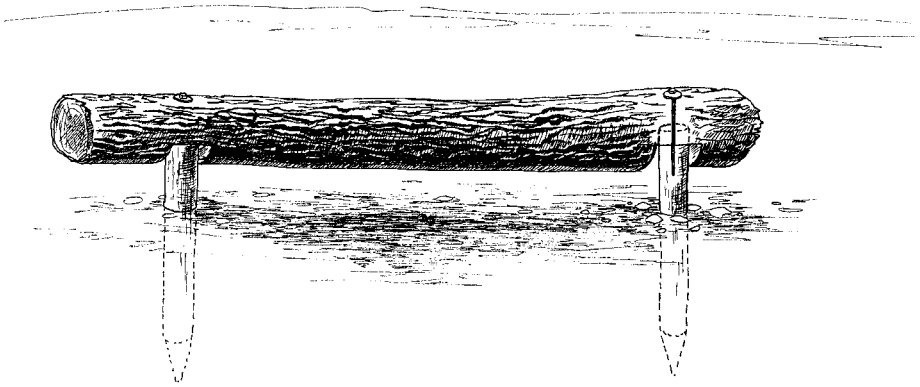
Channel Excavation with Whole Log Covers and Boulders

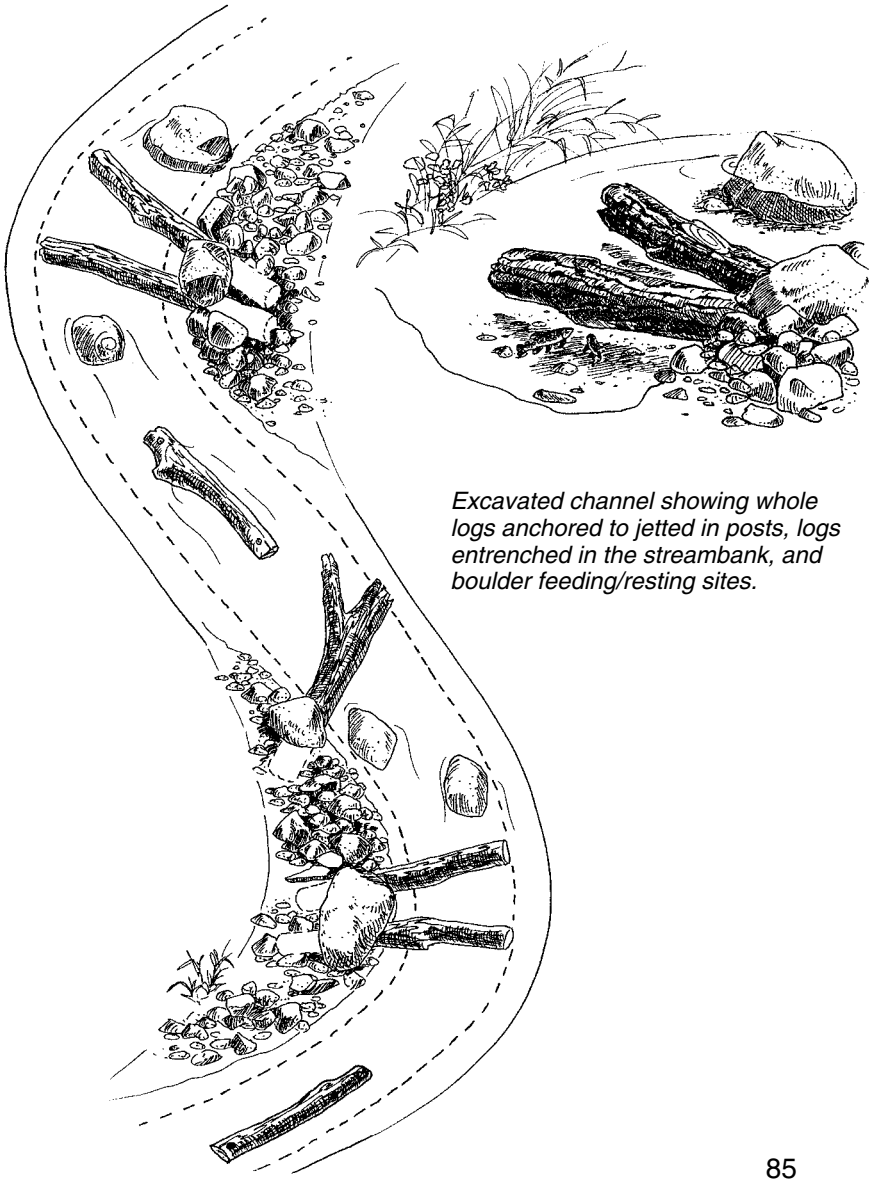
This technique is used on potentially good, low gradient, trout streams having an abnormally wide, shallow, sediment-filled channel. Streams that exhibit these characteristics are generally the result of early 20th century log drives, long-term beaver activity, or both. Heavy excavation equipment is used to dig a narrow, deep channel and whole logs or notched whole logs are pinned in place within the new channel to provide additional overhead cover.

On newly exposed firm substrates, half-inch holes are bored near the ends of each log and 6 ft. lengths of half-inch steel re-enforcement rods are inserted through the holes. One or two predrilled spacer blocks are then slipped onto each rod to hold the log off of the stream bottom so trout can slip underneath. On soft substrates, a notched whole log is anchored at both ends to anchored posts using lag bolts. Logs are positioned parallel with stream flow so that "dead water space" is provided beneath the log. A double whole log cover, where 2 logs are installed side by side, may be used if only smaller logs are available. The steel re-enforcement rods are typically prepared with a welded washer cap on top and then pounded in flush with the log. Rods without a welded cap are driven into the bottom until about 6 inches of rod protrudes above the log. This tip is then bent over in a downstream direction to anchor the log against the bottom.

Another common modification of the whole log cover embeds one end of a log into the inside bend with the excavator when re-channeling the stream. A boulder is placed on the entrenched end of the log to secure it before burial. A minimum of 40% of each log is buried, with the remainder suspended over the stream channel. As an adjunct to this technique, a few large boulders can be placed in mid-stream to create trout feeding sites.

Notched whole log pinned to jetted in posts (side view).





Excavated channel showing whole logs anchored to jetted in posts, logs entrenched in the streambank, and boulder feeding/resting sites.

Stream Bank Debrushing and Brush Bundles

During the early 1970's the cutting of woody vegetation along Wisconsin trout streams was focused on small, densely shaded streams. The most common "problem" vegetation was the speckled alder brush (Alnus *spp.*). Initial removal efforts consisted of cutting 100% of the woody vegetation from both stream banks along 30 ft. wide strips. Healthy, larger trees, if sparse in distribution, were bypassed. None of the cut brush was utilized to build brush bundles for in-channel placement.

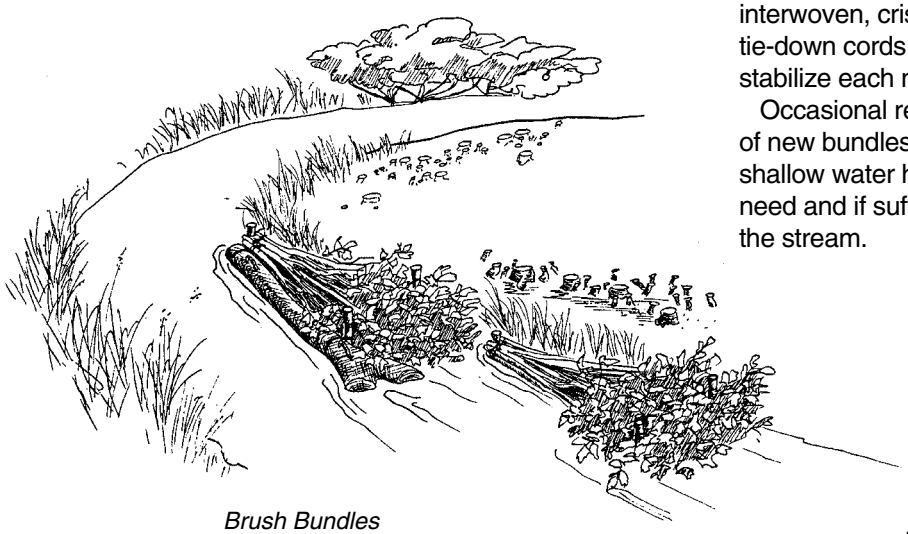
However, in the late 1970's stream bank debrushing became less intensive, and much of the cut brush is now put to good use in construction of brush bundles. Brush bundles can vary in size, placement location, and design. The most common procedure is to locate them on the lower inside edges of bends where deposition of water borne materials naturally occurs. Bundles accelerate the deposition process and speed up establishment of stable encroaching banks that help in concentrating stream flow along the outside bends. This may deepen the stream channel and increase undercut banks that provide most of the hiding cover for trout in small streams.

Brush bundles that are placed along the shallow side of stream channels can provide additional cover for small trout and serve as an attachment substrate for invertebrates. One simple technique to create a brush bundle consists of placing 3 wooden stakes extending 3 to 4 ft. above the water in a triangular configuration at the tip of an inside bend. Cut brush is placed in the triangle area with the butt ends facing upstream. Several butts are then lashed together and tied to the upstream stake. An anchoring cord is also tied across the brush between two of the lower stakes to help consolidate brush mass and provide stability.

If dead or undesired trees have been removed, portions of the main trunk can be positioned along the outside edges of brush bundles to provide longer functional life to the bundle and help deflect stream flow to the opposite, outside bend.

Brush mats have been used effectively along excessively wide and shallow reaches of stream that carry above-normal sediment loads. Such mats consist of interwoven, crisscrossed brushy material. A series of tie-down cords and stakes are used to compact and stabilize each mat.

Occasional refurbishing of brush bundles or addition of new bundles is an option worth pursuing where shallow water habitat for young trout is a high-priority need and if sufficient material is available to cut near the stream.



Brush Bundles

Brush Mat

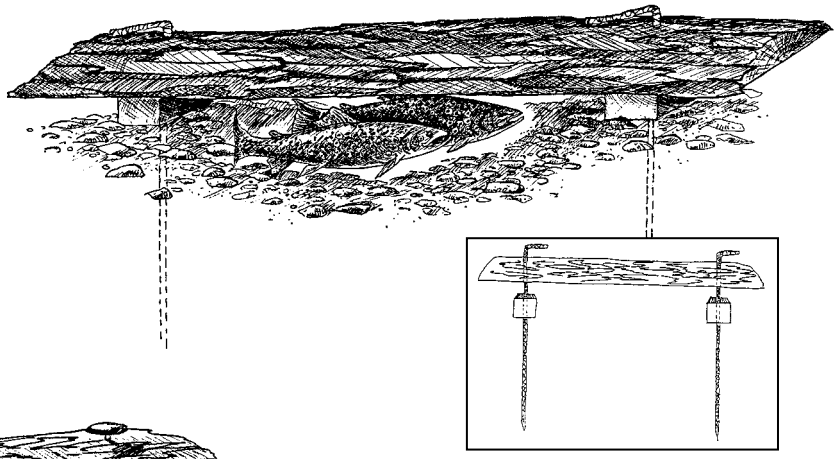
Half-logs

These simple, economical structures are used to provide resting and security cover for yearling and older trout in reaches of stream having sparse in-stream cover. Half-logs function best when installed on stable substrates. Excellent sites include the margins of major flow concentrations in “runs” or “flat water” reaches and in or near the edges of pools; half-logs can also be tied in at the head or tail of good natural cover for adult trout, to extend the value of such sites.

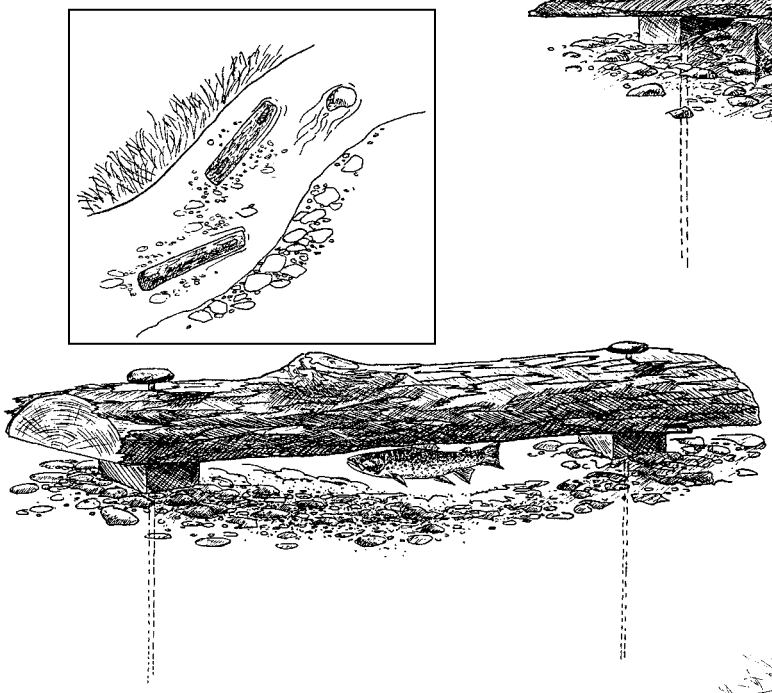
The most common material used for half-logs is green-cut oak. Eight to 10 ft. longitudinally cut sections will provide 2 half-logs. Half-inch holes are drilled near the ends of each half-log and lengths of half-inch steel reinforcement rods are inserted through the holes. Spacer blocks are slipped onto each rod, resting against the flat side of the log, keeping the half-log off of the stream bottom.

Half-logs should be positioned parallel with stream flow so that “dead water space” is provided beneath the log. The steel re-enforcement rods are typically prepared with a welded washer cap on top and then pounded in flush with the log. Rods without a welded cap are driven into the bottom until about 6 inches of rod protrudes above the log. This tip is then bent over in a downstream direction to anchor the log against the bottom.

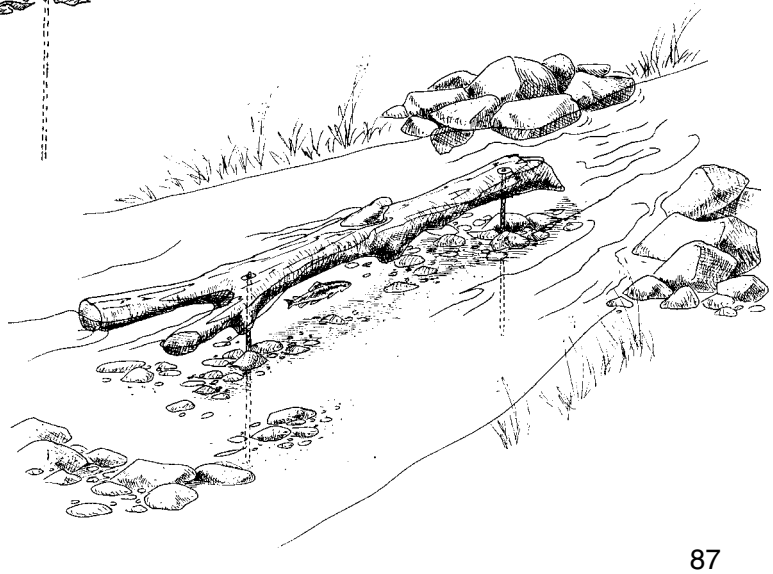
Common modifications to the half-log technique include the use of slab logs and whole logs. Slab logs, because they tend to be thinner, have special utility in providing mid-channel cover in shallow reaches, particularly in areas where trout spawn. Crooked whole logs may be pinned directly to the stream bottom and can provide overhead cover for most of their length. Whether half-logs, slab logs, or whole logs are used, the final product should be entirely submerged to slow rotting. However, whole logs may be partially exposed to provide “sunning” areas for turtles.



Slab log cover. Inset shows construction details.



Half-log cover. Inset above shows in stream position of half-logs.



Whole log cover.

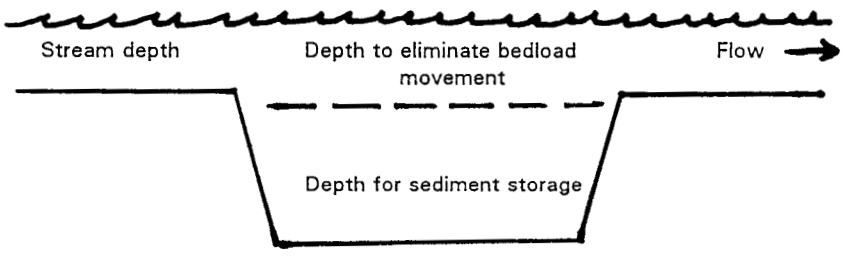
Sediment Trap and Gravel Spawning Riffle

Wisconsin has hundreds of miles of high quality trout water that lack gravel spawning areas. Many of these streams have excellent natural reproduction in their headwater reaches but sand and silt substrates predominant in their lower reaches decrease recruitment. Trout populations in Wisconsin are either dependent upon recruitment from upstream areas or upon the stocking of domestic trout. This habitat development technique was adopted in an attempt to establish self-sustaining trout populations in these lower stream reaches. Success of this technique in Michigan streams and several qualitative successes in Wisconsin give merit to the technique.

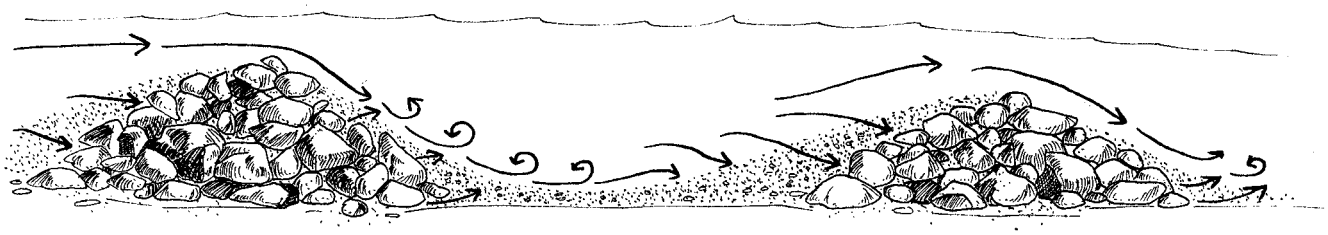
A sediment trap is a long hole excavated in a straight, shallow, reach of stream using heavy equipment operated from the stream bank. Water entering the “hole” slows, causing a loss of suspended sediment. Water exiting the “hole” has more energy to pick up sediments and scour areas immediately downstream. The length of the excavated area is dependent upon stream discharge, annual movement of sediment, and heavy equipment access. Normally, a sediment trap can range from 100 to 250 ft. long.

Excavation begins downstream and progresses upstream. A backhoe removes sediments from the entire width of the stream to depths of 5 to 7 ft. Stream width should not be increased. Removed sediment is transported out of the wetland and deposited in adjacent upland areas where it is leveled out to dry. Excavation is often completed during winter months when the stream banks are frozen facilitating heavy equipment access and minimizing riparian damage. Subsequent “clean-out” of the sediment deposited in the trap is done when the trap is at least three-quarters full. This may occur several times during the first year but thereafter once a year should be sufficient. Lengthening the trap to achieve this goal should be included in a contingency plan. Placing a sediment trap above a marginal gravel area where trout already spawn will improve both the quality and quantity of gravel exposed downstream.

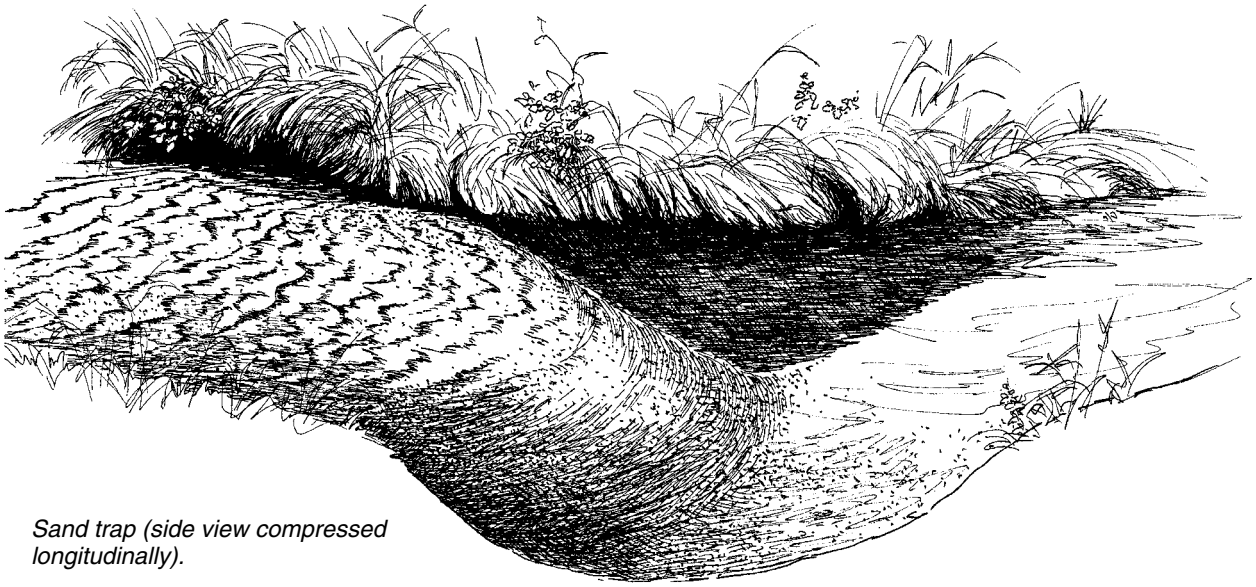
Construction of a rock-sill-and-gravel riffle should occur downstream and adjacent to a sediment trap. The riffle should be constructed in a relatively straight reach of stream. This may require placing it around a bend below the sediment trap. The length of the riffle is arbitrary but 50 to100 ft. is usually customary. First, the stream bed is covered with fabric to permit movement of water but prevent sinking of construction materials into underlying sediments. Three or 4 rock sills constructed of 8 to16 inch fieldstone are placed across the stream. The rock sills will help prevent the gravel from being washed downstream during high discharge events. Sills should be from 4 to 7 ft. wide at the base and taper up to just below the surface of the water. Distance between sills is dependent on water volume and stream velocity during high water. Too short a spread may cause turbulence to flush the gravel from the sill during high water. A sill spacing of 15 to 25 ft. is appropriate for most streams; a blanket of gravel 12 to 16 inches deep is spread between sills and above the below the upper and lower sills. The gravel should be a washed mix of ¼ to 1 inch materials. Stream velocities between the sills should be within the normal limits established in the literature for the affected trout species. The height of the sills can be adjusted to increase or reduce stream velocities. Finally, installing 1 or 2 half-logs in place on each gravel bed between sills will provide security and resting cover for spawning trout.



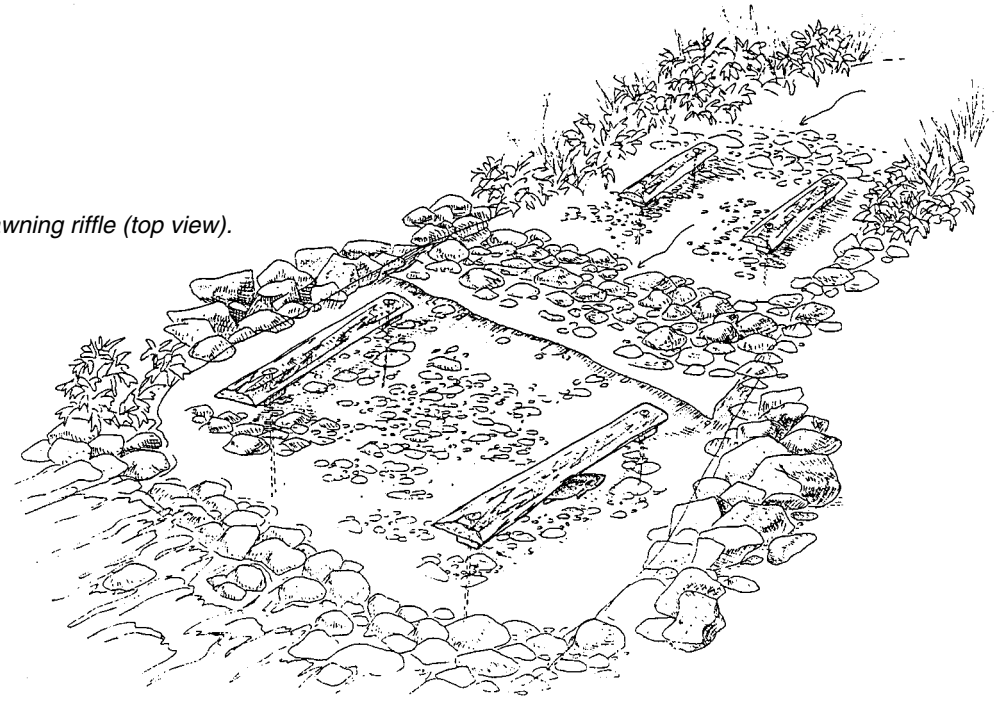
Sediment basin.



Rock sill and gravel riffle (side view).



Sand trap (side view compressed longitudinally).



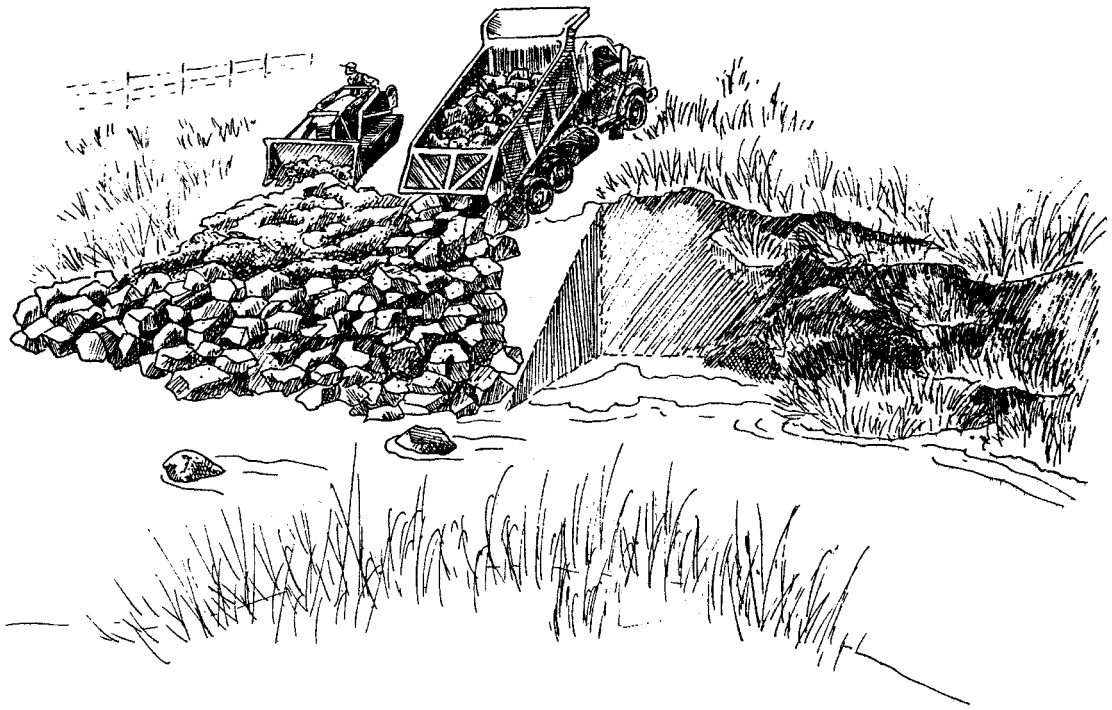
Rock sill and gravel spawning riffle (top view).

Riprap

This simple technique is normally used to repair and stabilize eroded stream banks. Narrowing of the stream channel may also be accomplished and hiding cover for trout can be enhanced by the interstitial spaces between rocks. The larger, more irregular in shape the rock used, the better. Therefore, quarried rock has advantages over fieldstone.

Most riprap projects are carried out in regions of Wisconsin that have erosion problems related to agricultural land use in the watershed. In these regions, access to reaches of stream with badly eroded banks is usually good, even for heavy equipment and dump trucks, especially after the ground has been frozen. Installation begins by using heavy equipment to slope the eroded banks to an approximate 30 to 45 degree profile. Rock is then dumped down the slope to create a base extending about 5 ft. out from the bank and 5 ft. to the top of the bank edge. The excavated material, removed in the sloping process, is placed back toward the stream to partially cover the top edge of the riprap hastening recovery of more esthetic appearances.

An alternate installation technique can best be described as “dump and push” without any preliminary sloping of eroded stream banks. Bank sloping is usually a site by site judgement call and increases the project cost. Sloping, however, does reduce the degree of channel narrowing when riprap is added.



Riprap

Appendix 1

Appendix 1. An index of the streams examined in this study. This table shows the 4 trout population characteristics measured in the study zones (TZ = treatment zone and RZ = reference zone), and whether these characteristics were successful or not in the TZs following habitat development. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase. See individual case histories for more details.

			Number of Study Zones		Trout Population Characteristics							
					Total Number of Trout per Mile		Number of Legal-size Trout per Mile		Number of Trout ≥6 Inches per Mile		Pounds of Trout per Mile	
Stream	**County**	**Trout Species Present**	**TZs**	**RZs**	**L1**	**L2**	**L1**	**L2**	**L1**	**L2**	**L1**	**L2**
Allen Creek	Forest	wild brook	2	0								
TZ1					No	No	Yes	Yes			Yes	Yes
TZ2					No	No	Yes	Yes			Yes	Yes
Allenton Creek	Washington	wild brook	1	1	Yes	Yes			Yes	Yes		
Big (Cataract) Creek	Monroe	wild and domestic brook	1	1	No	No			No	No		
Brown Spur Creek	Marinette	wild brook	2	0								
TZ1					Yes	Yes			Yes	Yes		
TZ2					Yes	Yes			Yes	Yes		
Cooks & Bullets Creek	Marinette	wild brook	2	0								
TZ1					Yes	Yes			Yes	Yes		
TZ2					Yes	Yes			Yes	Yes		
Camp Creek	Richland	wild brown	1	1	No	No	Yes	Yes			Yes	Yes
Chaffee Creek	Marquette	wild and domestic brown	1	1	No	No						
Clam River	Polk	wild brook, wild brown	1	0	No	No						
Davis/Clayton Creek	Waushara	wild brook, wild brown	1	1	No	No	Yes	Yes			Yes	Yes
Devils Creek	Rusk	wild and domestic brook, domestic brown	1	1	Yes	No	Yes	Yes			Yes	No
East Branch Eau Claire River	Langlade	wild and domestic brook and brown	1	1	Yes	Yes			Yes	Yes	Yes	Yes
Elvoy Creek	Forest	wild brook, wild brown	3	1								
TZ1					No	No	Yes	No			No	No
TZ2					No	No	Yes	Yes			No	No
TZ3					No	No	Yes	Yes			Yes	Yes
East Cataline Creek	Marinette	wild brook	1	0	Yes	No			No	No		
Emmons Creek	Portage	wild brown	1	1	No	No	No	No				
Ernst Creek	Marinette	wild brook	2	0								
TZ1					Yes	Yes			Yes	Yes		
TZ2					Yes	Yes			Yes	Yes		
Evergreen River	Langlade	wild brook, wild brown	1	1	No	No	No	No			Yes	No
First South Branch Oconto River	Oconto	wild brook, wild brown	1	0	No	No	Yes	Yes			No	No
Fordham Creek	Adams	wild brook, wild brown and domestic rainbow	1	0	Yes	No	Yes	Yes			Yes	Yes

Continued on next page

Appendix 1. Continued.

Stream	County	Trout Species Present	Number of Study Zones		Trout Population Characteristics							
					Total Number of Trout per Mile		Trout per Mile Number of Legal-size		Number of Trout ≥6 Inches per Mile		Pounds of Trout per Mile	
			TZs	RZs	L1	L2	L1	L2	L1	L2	L1	L2
Genricks Creek	Marinette	wild brook	2	0								
TZ1					Yes	Yes			No	No		
TZ2					Yes	Yes			Yes	Yes		
Hay Creek	Chippewa	wild brook, wild brown and domestic brown	1	1	No	No						
Hay Creek	Oconto	wild brook	1	1	No	No	No	No			No	No
Hunting River	Langlade	wild and domestic brook and brown	2	0								
TZ1							No	No			Yes	Yes
TZ2							No	No			Yes	No
K.C. Creek	Marinette	wild brook, wild brown	1	0	No	No	No	No			No	No
LaMontange Creek	Florence	wild brook, wild brown	1	0	No	No	Yes	Yes			No	No
Lepage Creek	Florence	wild brook	1	1	No	No					No	No
Little Evergreen Creek	Langlade	wild brook, wild brown	1	0	No	No	No	No			No	No
Little Roche A Cri Creek	Adams	wild brook, wild brown	1	0	Yes	Yes	Yes	Yes				
Lodi Creek	Columbia	wild brown	1	1	No	No	No	No				
Lost Creek	Marinette	wild brook	1	0	Yes	Yes			Yes	Yes		
Manley Creek	Sauk	wild brook	1	0					Yes	Yes		
McKenzie Creek	Polk	wild brown	2	0								
TZ1					Yes	No						
TZ2					Yes	Yes						
Mecan River	Waushara	wild brown	1	1			Yes	No				
Middle Branch Embarrass River	Shawano	wild brook	1	0	No	No	Yes	Yes				
Middle Inlet Creek	Marinette	wild brook	1	0	No	No	Yes	Yes			Yes	Yes
Millville Creek	Grant	wild and domestic brown	1	0	Yes	Yes	Yes	Yes			Yes	Yes
Murray Creek	Waupaca	wild brown	1	1	No	No	No	No				
Neenah Creek	Adams	wild brown	1	0	No	No						
No Name Creek	Marinette	wild brook	2	0								
TZ1					Yes	Yes			Yes	Yes		
TZ2					Yes	Yes			Yes	Yes		
North Branch Beaver Creek	Marinette	wild brook, wild brown	1	0	No	No	Yes	Yes			Yes	Yes
North Branch Pemebonwon River	Marinette	wild and domestic brook	1	0	Yes	No	Yes	Yes				
North Branch Prairie River	Lincoln	wild brook, wild brown	1	0	Yes	Yes	Yes	Yes				

Appendix 1. Continued.

Stream	County	Trout Species Present	Number of Study Zones		Trout Population Characteristics							
					Total Number of Trout per Mile		Trout per Mile Number of Legal-size		Number of Trout ≥6 Inches per Mile		Pounds of Trout per Mile	
			TZs	RZs	L1	L2	L1	L2	L1	L2	L1	L2
North Otter Creek	Forest	wild brook	1	0	No	No					Yes	Yes
Paradise Spring Creek	Waukesha	wild brook, wild brown	1	0	No	No					Yes	Yes
Prairie River	Lincoln	wild brook, wild brown	2	2								
R & H Road							Yes	Yes	Yes	Yes	Yes	Yes
Section 35							Yes	No	Yes	Yes	Yes	Yes
Price Creek	Sawyer	wild brook	1	0	No	No	No	No				
Rowan Creek	Columbia	wild brown	1	0	No	No	Yes	Yes				
Spring Brook	Ashland	wild brook	1	0	No	No	No	No				
Tomorrow River (upper)	Portage	wild brook, wild brown	1	0	Yes	Yes			Yes	Yes		
Twenty Mile Creek	Bayfield	wild brook, wild brown	1	1	No	No	Yes	Yes			Yes	No
Waupaca River	Waupaca	wild brook, wild and domestic brown	1	1	No	No						
Waupee Creek	Oconto	wild and domestic brook, wild brown	1	1	No	No						
Whitcomb Creek	Waupaca	wild brook	1	0	No	No	No	No				
Wisconsin Creek	Florence	wild brook	1	0	Yes	No	Yes	Yes				
Total			64	21								
Yes					24	18	24	21	16	16	19	15
No					34	40	12	15	3	3	8	12

Appendix 2

Appendix 2. An index of the streams examined in Hunt (1988). This table shows the 4 trout population characteristics measured in the study zones (TZ = treatment zone and RZ = reference zone), and whether these characteristics showed success in the TZs following habitat development. Level 1 (L1) success is a minimum 25% increase and Level 2 (L2) success is a minimum 50% increase. See Hunt (1988) for more details.

			Trout Population Characteristics							
			Number of Study Zones		Total Number of Trout per Mile		Trout per Mile Number of Legal-size		Pounds of Trout per Mile	
Stream	County	Trout Species Present	TZs	RZs	L1	L2	L1	L2	L1	L2
Allenton Creek	Washington	domestic brown	1	1	No	No			Yes	Yes
Beaver Brook	Washburn	wild brook and wild brown	1	1	Yes	No	Yes	No		
Behning Creek	Polk	domestic and wild brook	2	0						
TZ1					No	No	No	No		
TZ2					Yes	Yes	Yes	Yes		
Big Roche-a Cri. Creek	Waushara	wild brook	1	0	Yes	Yes	Yes	Yes	Yes	Yes
Clam River	Polk	wild brook and wild brown	1	0			Yes	No		
Coon Creek (Bohemian Valley)	La Crosse	domestic and wild brown	2	0						
TZ1					Yes	Yes				
TZ2					Yes	Yes				
Creek 12-6	Jackson	wild brook	1	0			No	No	No	No
Doc Smith Brook	Grant	domestic brown	1	0						
Apr TZ					No	No				
Oct TZ					No	No				
Dogtown Creek	Burnett	wild brook	1	0	Yes	Yes	Yes	Yes	Yes	Yes
Eddy Creek	Sawyer	wild brook	1	0	Yes	Yes	Yes	Yes	Yes	Yes
Elk Creek	Chippewa	wild brook	1	0	Yes	No	No	No	No	No
Emmons Creek	Waupaca	wild brown	1	1						
April TZ					No	No	No	No	No	No
October TZ					No	No	No	No	No	No
Foulds Creek	Price	wild brook	1	0	Yes	Yes	No	No	Yes	Yes
Hay Creek	Oconto	wild brook	1	1	No	No	No	No	No	No
Hunting River	Langlade	wild brook	2	0						
Station 1 TZ							Yes	Yes	Yes	Yes
Station 2 TZ							Yes	No	Yes	Yes
K.C. Creek	Marinette	wild brook and wild brown	1	0	No	No	No	No	No	No
Kinnickinnic River	St. Croix	wild brown	5	0						
Fuller TZ					Yes	Yes	Yes	Yes	Yes	Yes
Gibson 1 TZ					Yes	No	Yes	No	Yes	Yes
Gibson 2 TZ					Yes	No	No	No	Yes	No
Gibson 3 TZ					No	No	Yes	No	No	No
Purfeerst TZ					No	No	Yes	Yes	Yes	Yes
Kinnickinnic River	St. Croix	wild brook and wild brown	1	1						
April TZ					Yes	Yes	Yes	Yes		
October TZ					No	No	Yes	No		
Lawrence Creek	Adams and Marquette	wild brook	1	1	Yes	Yes	Yes	Yes	Yes	Yes
Lepage Creek	Florence	wild brook	1	1	No	No	No	No	No	No
Little Bois Brule River	Douglas	wild brook, wild brown, and wild rainbow	1	1	Yes	Yes			Yes	No
Little Plover River	Portage	wild brook	1	1	No	No	No	No		
Lunch Creek	Waushara	wild brown	1	1						
April TZ					No	No	No	No	No	No
September TZ					No	No	No	No	No	No
MacIntire Creek	Marinette	wild brook and wild brown	1	0	Yes	Yes	Yes	No	Yes	Yes

Appendix 2. Continued

Stream	County	Trout Species Present	Number of Study Zones		Trout Population Characteristics: Total Number of Trout per Mile		Trout per Mile Number of Legal-size		Pounds of Trout per Mile	
			TZs	RZs	L1	L2	L1	L2	L1	L2
McKenzie Creek	Polk	wild brown	1	0	Yes	No	Yes	No		
Middle Branch Embarrass River	Shawano	wild brook	1	0	No	No	No	No	No	No
Mt. Vernon Creek	Dane	wild brown	1	1	Yes	Yes			Yes	Yes
Neenah Creek	Adams	wild brown	2	0						
Station 1 TZ					Yes	Yes	Yes	Yes		
Station 2 TZ					Yes	Yes	Yes	Yes		
Nichols Creek	Sheboygan	wild brown	1	1	Yes	No	Yes	Yes		
North Branch Trempealeau River	Jackson	wild brook and wild brown	1	0	No	No	Yes	No		
Parker Creek	St. Croix	wild brown	2	0						
TZ 1					No	No	No	No	No	No
TZ 2					No	No	No	No	No	No
Plover River	Marathon	wild brook and wild brown	1	1			Yes	No		
Prairie River	Lincoln	wild brook and wild brown	2	2						
Sec. 35 TZ							No	No	Yes	Yes
Trantow TZ							No	No	Yes	Yes
Radley Creek	Waupaca	wild brown	2	1						
Station 2 TZ					Yes	No	Yes	No	Yes	No
Station 3 TZ					Yes	No	Yes	Yes	Yes	Yes
Rosenow Creek	Waukesha	wild brook and wild brown	1	0	Yes	Yes	Yes	Yes	Yes	Yes
Rowan Creek	Columbia	wild brown	1	1	No	No	No	No	No	No
South Fork Main Creek	Rusk	wild brown	1	1	Yes	Yes	Yes	No	Yes	Yes
Spring Creek	Chippewa	wild brook	1	1						
April TZ					Yes	No	Yes	No	Yes	No
October TZ					Yes	Yes	Yes	Yes	Yes	Yes
Tank Creek	Jackson	wild brook	2	1						
TZ 1					No	No	No	No	No	No
TZ 3					No	No	No	No	No	No
West Branch White River	Waushara	wild brown	1	0						
April TZ					Yes	Yes	Yes	Yes	Yes	Yes
October TZ					No	No	Yes	No	No	No
Willow Creek	Richland	wild brown	1	0			Yes	No		
Yellow River	Barron	wild brook and wild brown	2	0						
TZ 1					No	No	No	No		
TZ 2					No	No	Yes	Yes		
Total			55	20						
Yes					28	19	32	17	23	20
No					25	34	22	37	17	20

Literature Cited

The source documents used in preparing the case histories are not included in this list. Please see the individual case histories for a list of these documents.

Avery, E.L.
1983. Population dynamics of wild trout and associated sport fisheries in two northern Wisconsin streams. Wisconsin Department of Natural Resources *Technical Bulletin* 141:1-31.

Fausch, K.D. and R.J. White
1981. Competition between brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) for positions in a Michigan stream. *Canadian Journal of Fisheries and Aquatic Sciences* 38:1220-27.

Hunt, R.L.
1988. A compendium of 45 trout stream habitat development evaluations in Wisconsin during 1953-1985. Wisconsin Department of Natural Resources *Technical Bulletin* 162:1-80.

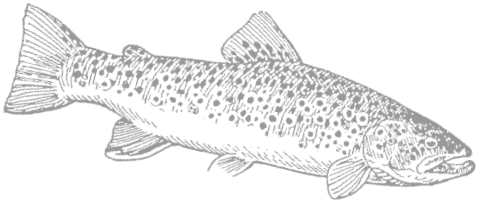
Hunt, R.L.
1993. *Trout Stream Therapy*. The University of Wisconsin Press, Madison, WI. 74 pp.

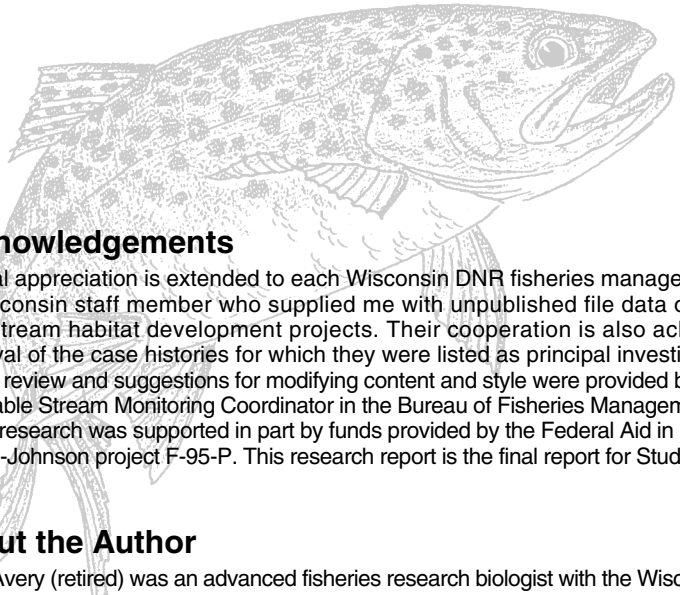
O'Donnell, D.J. and C.W. Threinen
1960. Fish habitat development. Wisconsin Conservation Department Publication No. 231. 15 pp.

Waters, T.F.
1981. Replacement of brook trout by brown trout over 15 years in a Minnesota stream: production and abundance. *Transactions of the American Fisheries Society* 112:137-146.

White, R.J. and O.M. Brynildson
1967. Guidelines for management of trout stream habitat in Wisconsin. Wisconsin Department of Natural Resources *Technical Bulletin* 39:1-64.

Wisconsin Department of Natural Resources
1980. *Wisconsin Trout Streams*. Wisconsin DNR, Madison, WI. 144 pp.





Acknowledgements

Special appreciation is extended to each Wisconsin DNR fisheries manager, technician, and University of Wisconsin staff member who supplied me with unpublished file data or reports on evaluations of trout stream habitat development projects. Their cooperation is also acknowledged for review and approval of the case histories for which they were listed as principal investigators.

Peer review and suggestions for modifying content and style were provided by Michael A. Miller, Baseline Wadeable Stream Monitoring Coordinator in the Bureau of Fisheries Management and Habitat Protection.

This research was supported in part by funds provided by the Federal Aid in Fish Restoration Act under Dingell-Johnson project F-95-P. This research report is the final report for Study SSMR.

About the Author

Ed L. Avery (retired) was an advanced fisheries research biologist with the Wisconsin Department of Natural Resources. His 33 years with the Wisconsin DNR focused on trout and other salmonid research. His mailing address is:

1206 Royalton Street
Waupaca, WI 54981

Production Credits

Martin P.A. Griffin, Editor
Michelle E. Voss, Layout/Production

Printed on recycled paper.

Wisconsin Department of Natural Resources
Bureau of Integrated Science Services
PO Box 7921, Madison WI 53707

PUB-SS-587 2004